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SEPTEMBER 1, 1994

COVER STORY:

Mixed analog-digital simulation

PG 38

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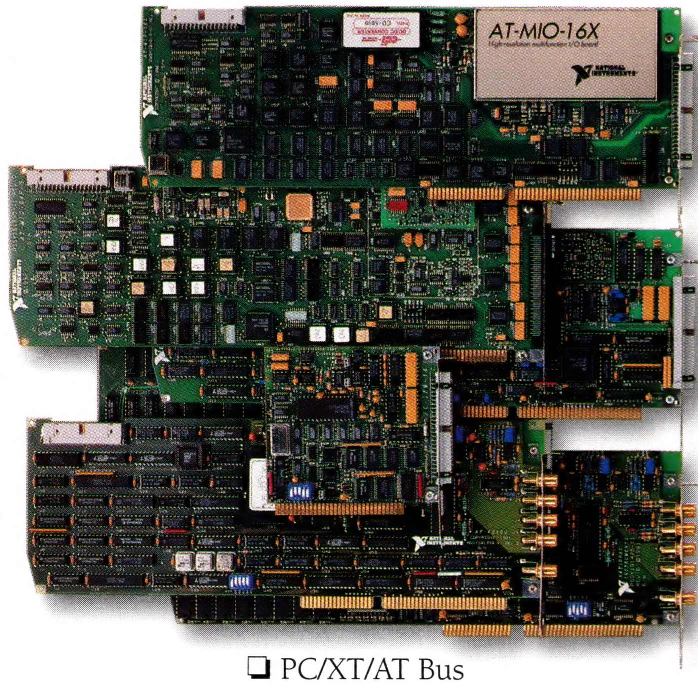
Multiple Choice.



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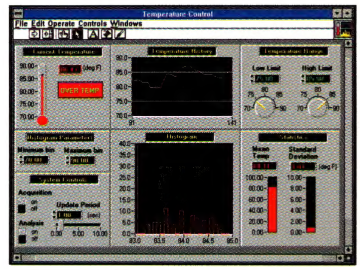
❏ PCMCIA



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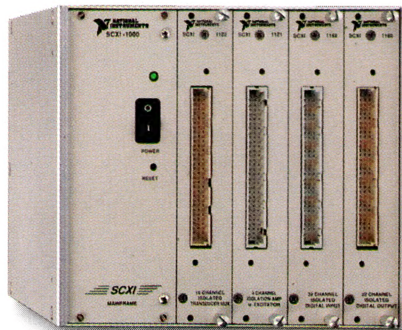

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EDN

DESIGN FEATURES

Out in Front

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EDN Products

EDN Departments

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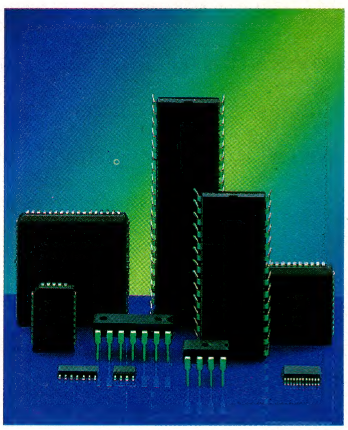

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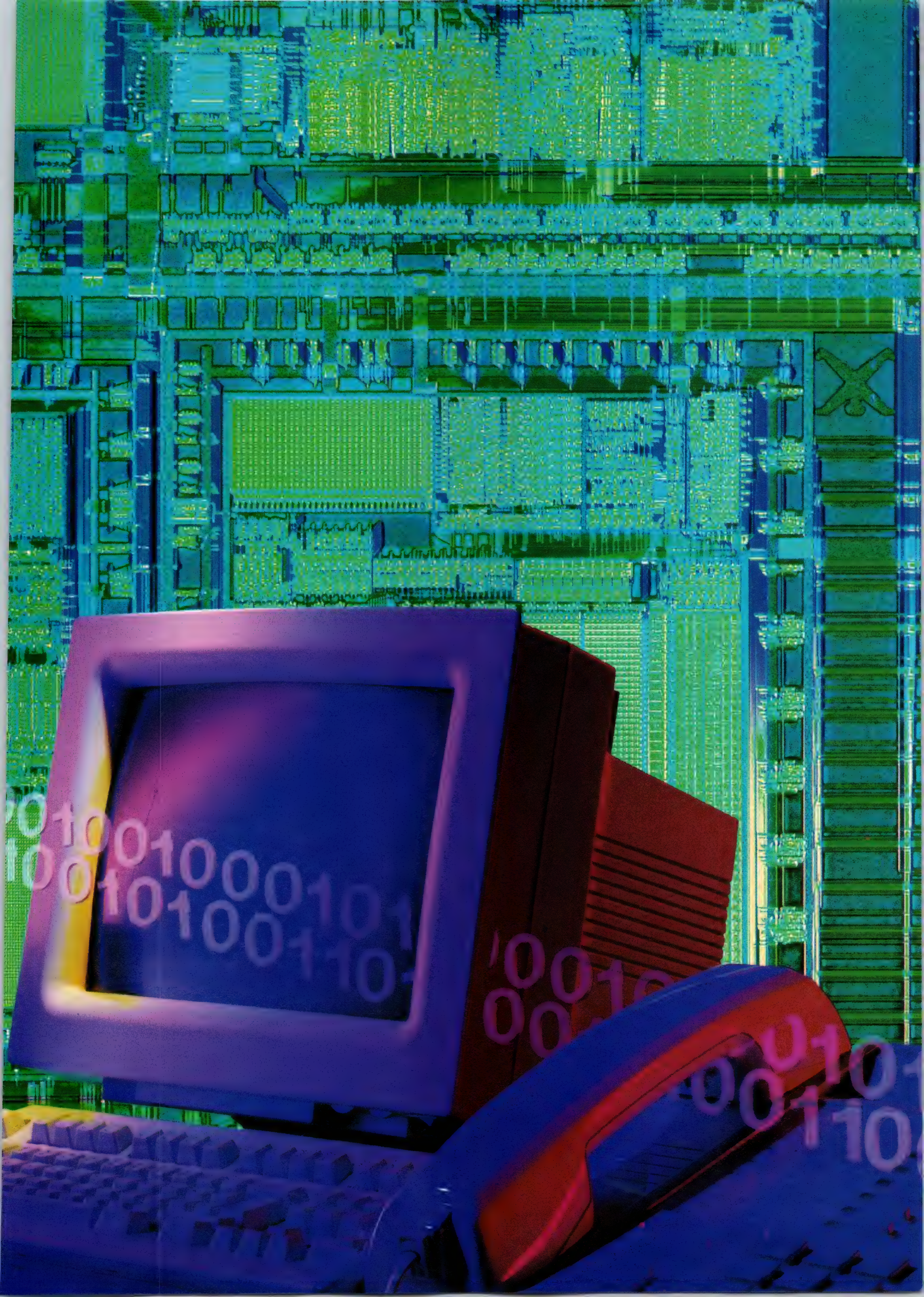

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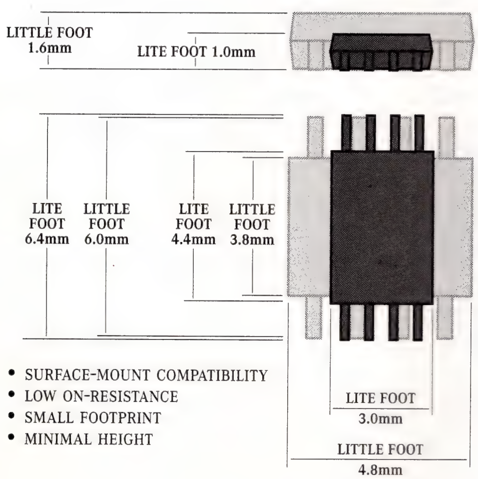

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LITE FOOT Part No.	TYPE	V_{DS} (V)	$r_{DS(on)}$ (mΩ)*	I_A (A)
Si6436DQ	Single N-Ch	30	50	4.2
Si6956DQ	Dual N-Ch	20	100	2.5
Si6433DQ	Single P-Ch	-12	75	3.5
Si6447DQ	Single P-Ch	-20	100	3.0
Si6953DQ	Dual P-Ch	-20	200	1.7
Si6542DQ	Complementary N-Ch P-Ch	 20 -20	 100 200	 2.5 1.7

* On-Resistance shown at V_{GS} = 10 V, except Si6433DQ shown at V_{GS} = 4.5 V

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SEVEN-CHIP SET BUILDS DIGITAL TV CAMERA

A seven-chip set of ICs from Hitachi lets you build small, CCD-based, digital-TV cameras. The chips comprise the H8/337 μC, the HA118144 correlated double-sampling/automatic gain-control (CDS/AGC) IC, the HD49306 9-bit A/D converter, the HD49801 video DSP, the HD49803 timing generator, the HD49307 three-channel, 8-bit D/A converter, and the HD49802 electronic-zoom IC. Because of the digital-camera architecture, this chip set reduces the number of camera adjustments to five from the typical 10. In addition, the DSP technology suppresses the false signals associated with CCD image sensors.

The digital-camera chip set accommodates CCDs with effective horizontal resolutions to 768 pixels. CCDs used with this chip set should employ the common color-difference line-sequential scanning system. The CDS/AGC IC amplifies and compensates the CCD's output signal and feeds the processed signal to the DSP.

The DSP generates 8-bit digital luminance (Y) and chroma (C) data from the processed CCD output in NTSC or PAL formats. All image-quality manipulation, including color clipping, gamma compensation, and color gain, occur within the DSP. For analog-output cameras, you can feed the digital output of the DSP directly to the chip set's three-channel D/A converter.

A member of the company's H8 μC family, the H8/337, controls all digital-camera functions. This μC incorporates a 32-kbyte program memory and 1 kbyte of RAM. You can get the device in masked or one-time-programmable (OTP) ROM versions. The OTP device is more expensive and generally used for development.

The chip set is available in several packaged versions. A prototype chip set, model HMM49111, costs $95. The HMM49101 basic production chip set costs $65 (10,000), and the HMM49104 basic production chip set with electronic zoom costs $85 (10,000).—by Steven H Leibson

Hitachi America Ltd, Brisbane, CA, (415) 589-8300.
Circle No. 577

Navigation tool for Internet

Digital Equipment Corp will provide the Mosaic navigation tool for the Internet with its computer systems, under a licensing agreement with Spyglass Inc, Champaign, IL. Spyglass is a commercial licensee of Mosaic for the National Center for Supercomputing Applications at the University of Illinois/Urbana-Champaign, developer of Mosaic. DEC will offer Mosaic on all of its computer systems, including Alpha AXP and Intel personal systems, others running the DEC OSF 1, OpenVMS, Windows, and Windows NT operating systems, and the Pathworks network operating system.

—by Fran Granville

Digital Equipment Corp, Maynard, MA, (508) 264-5358. **Circle No. 579**

Cost of ATM testing drops

Developers of asynchronous-transfer-mode (ATM) products should rejoice at the news that testing their prototypes no longer requires test sets that cost $45,000 or more. Pricing for Radcom's RC-200-C protocol analyzer begins at under $15,000. Moreover, the unit, which is based on a notebook PC running Windows-based software, accommodates plug-ins that adapt the device to fiber-optic and coaxial interfaces. Four plug-ins are available; a unit that includes all four costs less than $25,000.

—by Dan Strassberg

***Radcom**, Mahwah, NJ, (201) 529-1100.* **Circle No. 578**

This portable ATM protocol analyzer significantly cuts the cost of debugging prototype ATM products.

Wavetest users get two years to switch

When Wavetek Corp (San Diego) decided to exit from the data-acquisition and test-applications-development software market, the company felt obligated to its customer base. Wavetek is transferring responsibility for Wavetest to National Instruments (NI), which will provide support until June 1, 1996. In the interim, NI will work with users of Wavetest, Wavetest VIP, and Wavetest XTM to help them migrate to NI's data-acquisition application-development packages, LabView and LabWindows/CVI.

—by Dan Strassberg

National Instruments, Austin, TX, (512) 794-5760.
Circle No. 580

Vendors lower initial cost of VXI

From the start, the VXI community has maintained that the cost of VXI cages and modules is not a good indicator of real system cost. By the time you assemble a working VXI system and keep it running for a year or so, your costs would be lower than those for a system comprising more traditional instruments. Moreover, VXI proponents assert, your savings increase as you build and maintain more VXI systems. Although many system integrators have found this to be so, others were put off by VXI's initial costs.

Hewlett-Packard, a leader in B-size VXI modules, which are less expensive than the larger and more common C-size units, is working to lower VXI's initial costs. With embedded-controller supplier Radisys Corp and automotive and avionics test-equipment-supplier C&H Technologies Inc, HP's VXI catalog has recently added a number of low-cost products. Many of these are in (or for) B-size packages. The new products include B- and C-size card cages, C-size 64- and 100-MIPS PA-RISC embedded controllers ($8900 and $14,600), and a B-size embedded controller with various i486 CPUs (from $4000). Instrument modules include 32- and 64-channel B-size ADC modules ($3950 and $4900).

—by Dan Strassberg

C&H Technologies Inc, Austin, TX, (512) 251-1171. **Circle No. 581**

Hewlett-Packard Co, Santa Clara, CA, (800) 452-4844. **Circle No. 582**

Radisys Corp, Beaverton, OR, (503) 646-1800. **Circle No. 583**

Cahners acquires In-Stat. Cahners Publishing has acquired In-Stat, a market research company serving the electronics industry. In-Stat provides clients with information on 15 industry segments, custom consulting and consumer surveys, specialized market-research projects, and a monthly newsletter, *The In-Stat Electronics Report*.

Cahners Publishing Co, Newton, MA, (671) 964-3030. **Circle No. 584**

Handheld do-everything test tools undergo a rebirth

Since their 1991 introduction and their capture of an *EDN* Innovation award, Fluke Corp's ScopeMeters have by all accounts been some of the industry's most successful test-and-measurement products. Fluke, which has no intention of losing its sales lead, hasn't been sitting by idly. The company has made many improvements, particularly in ease of use. The result is the ScopeMeter Series II, which includes four $5^1/_4 \times 10^3/_4 \times 1^3/_4$-in. models, each of which weighs 4 lbs with batteries. The original units, models 93, 95, and 97, continue to be available.

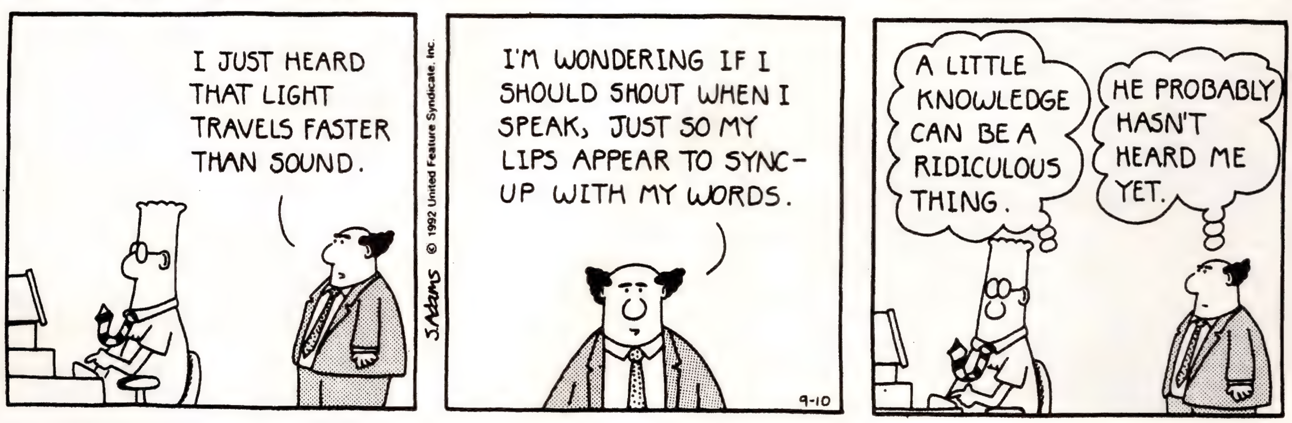
Like the originals, the Series II units combine ±3200-count DMMs with 50-MHz-bandwidth digital storage oscilloscopes. The 91 ($1295) has a single channel; the 92 ($1595), 96 ($1895), and 99 ($2195) have two. Compared with the 96, the 99 offers twice as many memories to store waveforms and setups. (The 91 and 92 do not offer such memories.) The 99 also performs waveform math and includes a signal generator and a component tester. Of the original family, only the 97 offers a back-lit display; in the Series II, all models offer such displays.

The new units make a noticeable improvement in display contrast, and the company has added a gray-scale capability. The displays are transreflective, which means that when the ambient light is good, you can turn off the backlighting and thus extend the battery life. With the backlighting on, the units operate for four hours from the included NiCd cells. Recharging the cells inside the units takes 16 hours, but an optional external charger does the job in about one-fifth that time. You can also substitute nonrechargeable alkaline cells for the NiCds and run the units for about six hours.

A measure menu gives you direct access to 33 measurements (18 on the 91 and 92). A mode that Fluke calls "continuous autoset" (but most users will proba-

(continued on pg 18)

DILBERT® by Scott Adams



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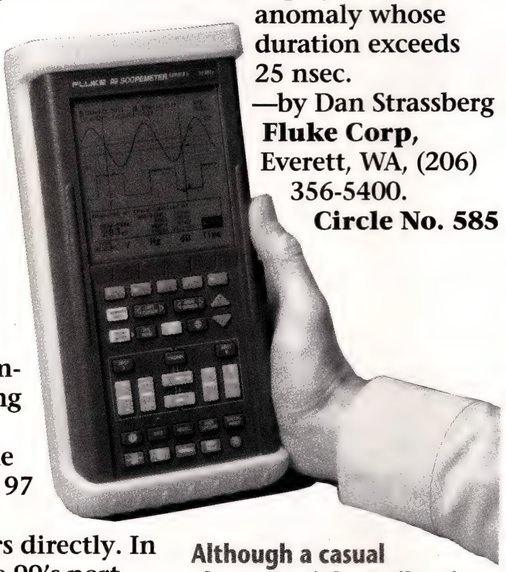
bly call "autoranging") searches for good-trigger, sweep-speed, and vertical-range settings every time you change the input signal. At any time, pressing a single button summons information on how to operate the controls; the information appears as a band of text across the screen. Of the original ScopeMeters, only the 97 provides an optically isolated RS-232C port. All four Series II models offer such ports; they allow transferring data to a host computer running appropriate software. The ports on the 97 and 99 also drive printers directly. In addition, the 99's port permits remote control.

In the meter mode, selecting "min/max" activates a TrendPlot feature that provides a graph of the input signal's moving average surrounded by graphs of the minimum and maximum values attained by the input over a time interval equivalent to 1 pixel. In the scope mode, the same selection displays the waveform's envelope. The scope mode also includes a glitch-capture feature that displays any signal anomaly whose duration exceeds 25 nsec.
—by Dan Strassberg

Fluke Corp, Everett, WA, (206) 356-5400. **Circle No. 585**



Although a casual observer might easily mistake the units in the ScopeMeter Series II for their still-available progenitors, the new units offer a bevy of features that enhances their usefulness.

Support grows for Serial Storage Architecture

Disk-manufacturer Micropolis has joined backers of the Serial Storage Architecture (SSA) with the production and shipment of prototype SSA disk drives to selected OEMs. SSA is a serial interface for mass storage that offers higher performance, easier integration, and larger configurations than today's parallel SCSI. It provides a total bandwidth of 80 Mbytes/sec and has lower overhead delays than SCSI, giving substantially higher performance at the subsystem level. SSA supports as many as 128 storage devices on a single link, and devices may be as much as 20m apart.
—by Gary Legg

Micropolis Corp**, Chatsworth, CA, (818) 709-3300.* ***Circle No. 586

ICE emulates 386/486 µPs to 50 MHz

The ERX 548 in-circuit emulator extends Zaxtek's 32-bit in-circuit-emulator (ICE) family into the x86 realm. Comprising the EZX main chassis and three ERX personality modules, the ICE can emulate processors with external bus speeds to 50 MHz, including the clock-doubled 66-MHz µPs. A proprietary, high-speed parallel interface connects the ICE to a host PC and downloads object code to the emulator at 1 Mbyte/sec. Real-time trace memory comprises 8192 80-bit words. You can trigger on as many as four preset breakpoints or break execution from the PC's keyboard. The ICE's ERX 548P personality module emulates the 80486DX, 80486DX2, 80486SX, and ODP486SX µPs and the 80487SX math coprocessor. The 80386DX version of the ERX 538P personality module emulates the 80386DX, TI486DLC, Am386DXL, Am386DXLV, and Cx486DLC µPs. The 80386SX version of the ERX 538P personality module emulates the 80386SX, TI486SLC, Am386SXL, Am386SXLV, Cx486SXC, and Cx486SXL-V µPs. The emulator with one µP personality pod, 1 Mbyte of emulation memory, and source-level debugging software costs $33,500.—by Steven H Leibson

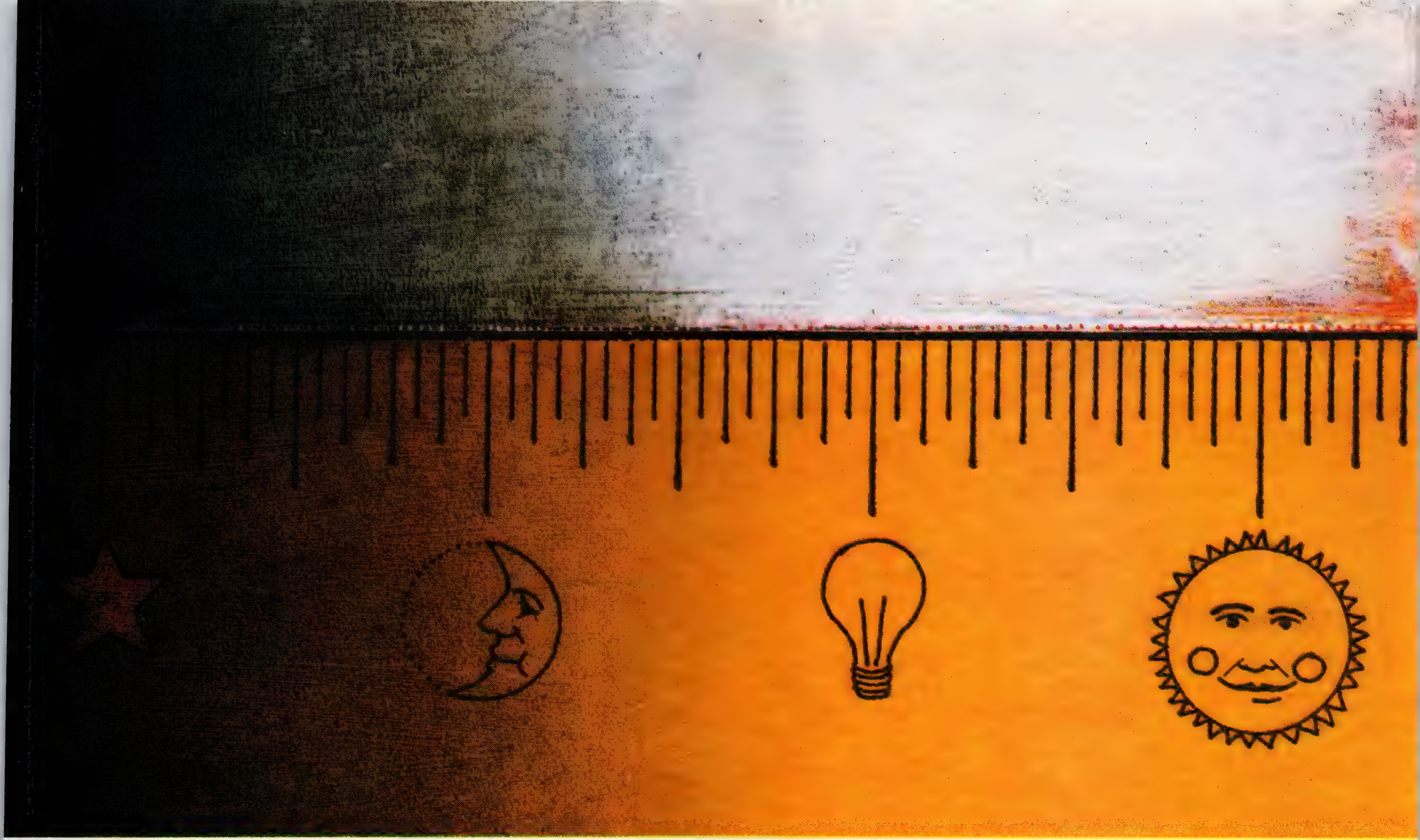
***Zaxtek**, Irvine, CA, (714) 474-1170.* **Circle No. 587**

PCI BUS CONFERENCE ISSUES CALL FOR PAPERS

Annabooks, a publisher and provider of information to designers of hardware and embedded systems, is sponsoring a new conference focusing on the technology and methods of designing, manufacturing, and marketing PCI-based components and computer systems. PCI '95, which *EDN* will co-sponsor, will take place April 5 to 7, 1995, in San Diego.

The organizer has invited participants to submit proposals in their areas of expertise for presentations, seminars, tutorials, or panels. Participants can also submit ideas for forums describing the problems and needs of manufacturers, distributors, value-added resellers, test engineers, product managers, software developers, and computer vendors. Topics of interest include bus design and compliance, comparisons with and bridging to other buses, market and sales trends, international markets, marketing methods, embedded applications, plug and play, PLDs, and more. Submit your proposals no later than Sept 30, 1994, to Dr Lance A Leventhal, Program Coordinator, PCI '95, Annabooks, 11848 Bernardo Plaza Court, Suite 110, Box 270708, San Diego, CA 92198-2708.—by Fran Granville

Annabooks, San Diego, CA, (619) 673-0870
Circle No. 588



Precision light measurement without costly A/D converters.

Now there's a remarkably simple way to process a wide dynamic range of light levels — with the all-new TSL230 current-to-frequency converter from Texas Instruments.

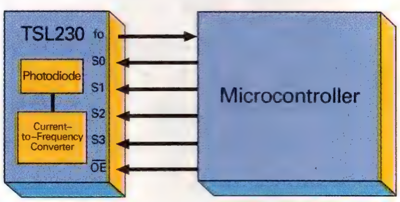
A single, low-cost chip that's beyond measure. TI extends your reach with the first opto device that offers you a high-resolution conversion of visible and near-infrared light into digital format — all on a single chip. Meaning you can eliminate the need for external op amps, A/D converters and discrete photodiodes.

The TSL230 is a monolithic combination of a configurable photodiode and a high-resolution current-to-frequency converter packed into one cost-effective, clear-plastic 8-pin DIP. And it interfaces directly with your microcontrollers.

TSL230 Technical Specifications

- 16-bit or 1 microsecond light-level measurement
- 160 dB input dynamic range
- Digitally programmable sensitivity
- 2.7- to 6-V operation
- 100 ppm/°C temperature coefficient
- 0.2% nonlinearity at 100 kHz
- $2.76 each in quantities of 1,000

Simple Microcontroller Interface



Its performance attributes shine bright. The TSL230 lets you reduce system cost and minimize design complexity in such applications as fluid opacity, light measurement and control, and industrial process controls.

Want us to shed more light? To learn more about the TSL230, simply circle the reader response number below.

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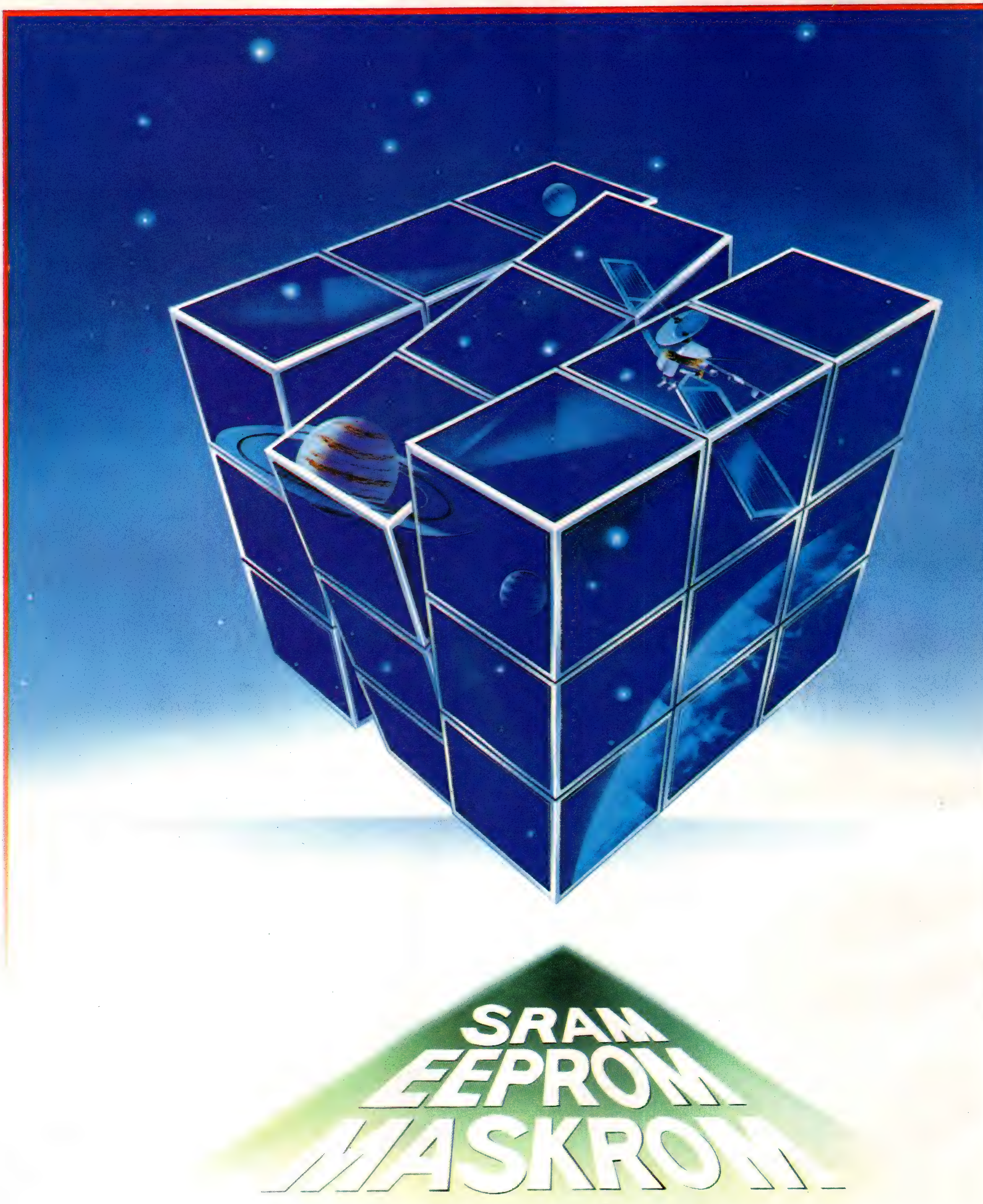
TEXAS INSTRUMENTS

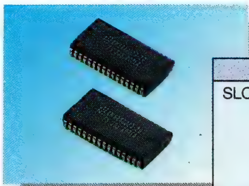
CIRCLE NO. 107

00-8732P
SOEE043ED401R


SRAM
EEPROM
MASKROM

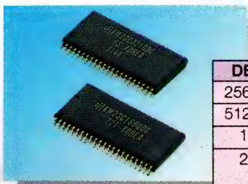
Diverse features focused On One Point, Sophisticated Technology.

Samsung creates new value from advanced memory technology.



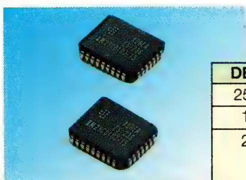
SRAM

	DENSITY	ORG.	SPEED	PKG	REMARK
SLOW	64K	X8	70/100/120	28DIP/SOP, 28SDIP	
	256K	X8	(55)/70/85/100/120	28DIP/SOP, 28TSOP (I)	55ns, 3.0V:2Q'94
	512K	X8	55/70/100	32SOP, 32TSOP (I)	
	1M	X8	55/70/85/100/120	32DIP/SOP, 32TSOP(I)	3.0V:2Q '94
	4M	X8	45/55/70/100	32DIP/SOP, 32TSOP (II)	3.0V AVAILABLE
FAST	64K	X4	15/20/25	22DIP, 24SOJ	
		X8	15/20/25	28DIP/SOJ	
	256K	X4, X8	6/7/8 (BiCMOS)	28, 32SOJ	CENTER PWR
		X4, X8	8/10/12 (BiCMOS)	28SOJ	CORNER PWR
		X4, X8	(12)/15/20/25	28SOJ	12ns:2Q '94 3.3V/15ns:3Q '94
	288K	X9	9/10/12 (BiCMOS)	32SOJ	
	4M	X4, X8	20/25	32SOJ, 36SOJ	
		X16	20/25	44SOJ	
	1M	X4, X8	8/9/10/12 (BiCMOS)	32SOJ	
		X4, X8	20/25/35	28DIP/SOJ, 32DIP/SOJ	CORNER PWR
		X4, X8	15/20	32SOJ	CENTER PWR
		X16	15/17/20	44SOJ	CENTER PWR
SPECIALTY	1M	64KX18 (S.B)	8/9/10/12	52PLCC	P5 CACHE
		256KX4 (S.P)	10/12.5	36SOJ	MIPS R 4000/R 4400



MASK ROM

DENSITY	PART NO.	ORGANIZATION	SPEED(ns)	PACKAGE
256K BIT	KM23C256X	32K X 8	120/150	28DIP/32SOP
512K BIT	KM23C512X	64K X 8	120/150	28SIP/32SOP
1M BIT	KM23C10XX SERIES	128K X 8	120/150	28DIP/32DIP/32SOP
2M BIT	KM23C2X0X SERIES	256K X 8 126K X 16	100/120	32DIP/32SOP/40DIP
4M BIT	KM23X4X0X SERIES	512K X 8 256K X 16	100/120/150	32DIP/32SOP/40DIP/40SOP
8M BIT	KM23X8X0X SERIES	1M X 8 512K X 16	100/120	32DIP/32SOP/42DIP/44SOP
16M BIT	KM23X16X0X SERIES	2M X 8 1M X 16	120/150	42DIP/44SOP/36DIP
32M BIT	KM23C32X0X SERIES	4M X 8 2M X 16	150/200	42DIP/44SOP/70SSOP



EEPROM/FLASH

DENSITY	PART NO.	ORGANIZATION	SPEED(ns)	PACKAGE
256 BIT	KM93C06/07	16 X 16	1 MHz	8DIP/8SOP
1K BIT	KM93C46 SERIES	64 X 16	1 MHz	8DIP/8SOP
2K BIT	KM93C56 SERIES KM93C57 SERIES	128 X 16 128 X 16 256 X 8	1 MHz 1 MHz 1 MHz	8DIP/8SOP 8DIP/8SOP 8DIP/8SOP
4K BIT	KM93C66 SERIES KM93C67 SERIES	256 X 16 256 X 16 512 X 8	1 MHz 1 MHz 1 MHz	8DIP/8SOP 8DIP/8SOP 8DIP/8SOP
	KM28C16/J/I KM28C17/J/I	2K X 8 2K X 8	150/200/250 150/200/250	24DIP/32PLCC 28DIP/32PLCC
64K BIT	KM28C64A SERIES KM28C65A SERIES	8K X 8 8K X 8	120/150/200 120/150/200	28DIP/32PLCC 28DIP/32PLCC
1M BIT	KM29C010/J/T	128K X 8	100/120/150	32DIP/PLCC/TSOP
16M BIT	KM29N16000T	2M X 8	80	44(40)TSOP (II)

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Reader adds more pieces to simulation puzzle

Regarding "System simulation embraces real-time control prototyping" (*EDN*, May 26, 1994, pg 49) by Senior Technical Editor Brian Kerridge, while we at Applied Dynamics International (ADI) agree with its basic premise, it appears that the author failed to do his homework. Of the 10 companies listed on pg 56, only two are common names in the real-time system-simulation arena. The article missed several legitimate vendors, for instance ADI, Xanalog, and Harris.

Secondly, the article implies that the only way to perform system simulation is by utilizing "a DSP test bed." The 32-bit DSP represents the low end of compute power in price/performance for complex system simulation. The DSP is totally inadequate for the level of numerical integration accuracy required in simulating very stiff systems—those characterized by a broad range of frequency content. Today's RISC technology, which can handle both 32- and 64-bit computations, is a far better choice of compute power for those who are serious about doing simulation jobs properly.

Mr Kerridge also states that "Increasing system power is simply a matter of installing more DSP hardware, and all systems include multiprocessing expansion for this purpose." Although most systems do support multiple processors, utilizing multiple processors can be very cumbersome if the system supplier doesn't supply easy-to-use software tools for handling multiple numerical integration frame rates, intra- and interprocessor communications, multiprocessor/multilanguage (Fortran and C) symbolic debugging, etc. Moreover, using multiple processors doesn't guarantee a solution. Adding more processing power is the easy part; being able to do something *useful* with the additional compute power is where the fun begins!

ADI has been providing real-time simulation systems since 1957. We have a reputation for solving the most demanding simulation problems. We have recently teamed with Boeing Computer Services and General Electric to provide the most comprehensive set of systems engineering tools available—including integrated rapid prototyping tools.

Robert L Goffee
Applied Dynamics International
Ann Arbor, MI

Sound off

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CIRCLE NO. 4

Philips Semiconductors
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For more information on any of these subjects: call 1-800-447-1500 and request appropriate extension number.

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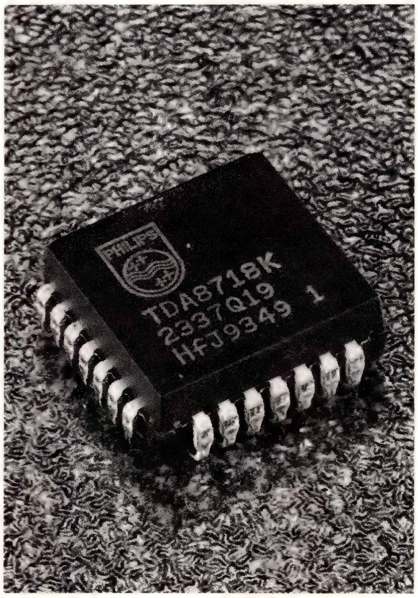
Ultra-fast 8-bit A/D converter provides unique performance



The TDA8718 provides a unique combination of very high sample rate, wide input bandwidth and low power consumption.

Capable of digitizing an analog signal at up to 600 Msamples per second while maintaining an effective 8-bit signal bandwidth of 150 MHz, the new TDA8718 8-bit high-speed A/D converter is designed for use in professional applications such as disk drives, digital storage oscilloscopes, digital radio receivers and satellite communications equipment. Its very high sample rate gives it a usable input bandwidth of 150 MHz, while its low power dissipation of only 1 W helps to reduce overall power consumption.

The TDA8718's wide input bandwidth and excellent dynamic performance are made possible by a specially-designed analog input stage which reduces the input capacitance to a mere 5 pF and eliminates the need for external sample-and-hold circuitry for input signals up to 150 MHz. To allow the input range to be adjusted to suit different analog signal amplitudes, both ends and the center point of the on-chip 48 Ω reference divider ladder are led out to device pins. This allows the input amplitudes corresponding to digital zero and digital full-scale to be easily set by an external voltage reference.

The A/D conversion results in 8-bit binary coded data, plus separate overflow and underflow flags, which appear at ECL-100k-compatible outputs that can drive 50 Ω loads. The TDA8718 operates from a –4.5 V supply and has an operating temperature range of 0 to +70°C.

Call 1-800-447-1500 Ext 1135
Europe: circle no. 40

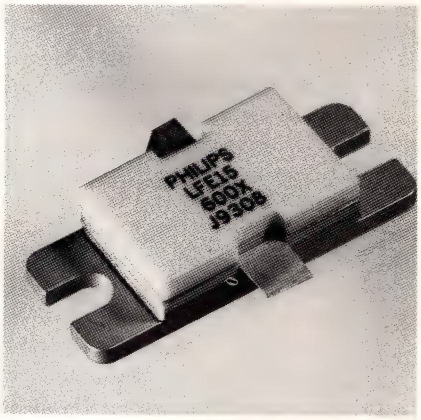
Single-ended silicon microwave transistor delivers 60 W

The LFE15600X silicon npn microwave power transistor is the first single-ended 60 W device suitable for use in the class AB output stages of transmitters operating in the 1.5 to 1.7 GHz frequency band.

The LFE15600X's single-ended base input, plus its high power handling and diffused emitter resistors, allow transmitter powers of several hundred watts to be achieved by connecting a number of the devices in parallel, without the need for complex input-matching circuitry. The device's very low level of third-order intermodulation distortion, typically better than –30 dBc at 60 W PEP, suits it for use in multi-carrier transmitters such as those found in PCS/PCN base stations, as well as in transmitters for mobile satellite communications.

The transistor achieves a typical full-power collector efficiency of 50% at a junction temperature of 100°C which results in lower operating temperatures and excellent long-term reliability. Typical power gain is 8.5 dB at 1.5 GHz, permitting simpler driver stage design.

Call 1-800-447-1500 Ext 5016
Europe: circle no. 41



The LFE15600X microwave power transistor is housed in an FO-231 metal/ceramic flanged package.

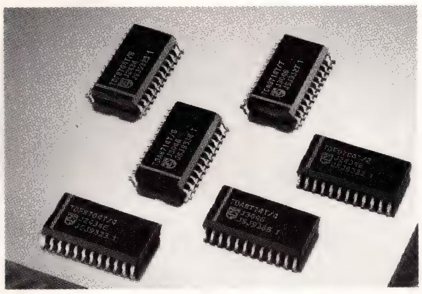
Philips Semiconductors

High-speed 8-bit A/D converters are ideal for low-voltage, low-power applications

Two new high-speed 8-bit A/D converters have been introduced for use in video signal processing, transient/pulse analysis and general industrial applications. Both converters operate from 5 V supplies and only dissipate around 350 mW, making them ideal for applications requiring non-multiplexed multi-channel A/D conversion coupled with low overall power consumption.

The TDF8704, which has the –40 to +85°C operating temperature range required for automotive and industrial applications, digitizes at up to 50 Msamples per second. Sampling a 4.43 MHz full-scale analog input at this rate, it achieves 7.4 effective bits. Total harmonic distortion is typically –60 dB and its usable input bandwidth extends to 10 to 15 MHz. Designed for stand-alone operation, the TDF8704 has a stable on-chip voltage reference with low drift with respect to both temperature and supply voltage.

The TDA8714, which is designed for professional applications in areas such as video, radar, medical imaging and research physics, operates with external voltage reference inputs that set the analog input range. It has a higher



The TDF8704 and TDA8714 high-speed A/D converters are housed in 24-lead SO packages. The TDA8714 will also be available in the 24-lead shrink small outline plastic (SSOP) package.

sampling rate of 75 Msamples per second which allows it to achieve 7.7 and 7.3 effective bits respectively for input signals of 4.43 and 10 MHz. The TDA8714 is still effective at digitizing input signals as high as 15 to 20 MHz.

The ICs are also available in lower speed versions with sample rates of 40 or 20 Msamples per second for the TDF8704 and 60 or 40 for the TDA8714.

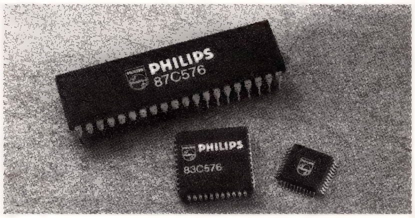
Call 1-800-447-1500 Ext 1136
Europe: circle no. 42

Feature-packed 80C51 offers highest integration level and system reliability

The latest addition to Philips Semiconductors' wide range of 80C51-based 8-bit microcontrollers is the most feature-packed on the market. The 8XC576 offers a highly integrated controller with UPI (Universal Peripheral Interface) and a 10-bit A/D converter, simplifying board design and eliminating the need for external components. The device improves system fault tolerance with low electromagnetic and RF emissions.

The 8XC576 addresses a broad range of applications including automotive and industrial control, data communications, instrumentation, medical electronics, computers and peripherals and cellular/wireless networks. By demonstrating greatly reduced EMI/RFI emissions, the 8XC576 ensures easier compliance with EU and FCC standards; while exact savings are application dependent, the new microcontroller has reduced emissions by more than 20 dB in some designs.

Additional features of the 8XC576 include: 8 kbytes of ROM (83C576) or EPROM



The 8XC576 8-bit microcontroller is the most feature-packed 80C51 derivative on the market.

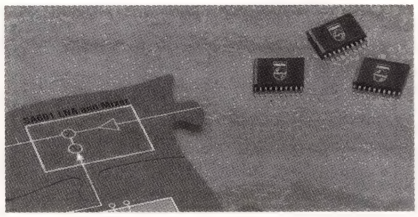
(87C576), 256 bytes of RAM, three 16-bit counters/timers, programmable counter array, on-chip watchdog timer, analog comparators, enhanced UART, two PWM outputs, power and oscillator fail detection, user-programmable outputs and Schmitt trigger inputs. The 8XC576 is software-compatible with earlier 80C51 derivatives and packaging options include plastic and ceramic dual-in-line package and leadless chip carrier.

Call 1-800-447-1500 Ext 1137
Europe: circle no. 43

New RF front-end IC reduces cost and complexity of 900 MHz wireless designs

The new low-voltage SA601 RF IC integrates all the front-end functions needed for a variety of 900 MHz wireless receiver applications. It offers benefits of simplified design, small size, low power consumption and low cost to system designers.

The SA601 incorporates a low noise amplifier (LNA), down-convert mixer, local oscillator buffer and temperature and supply voltage compensating bias circuitry in one small 20-lead SSOP surface-mount package. Total current draw is only 7.4 mA at 3 V. The SA601 provides a complete RF receiver front-end solution for American and European analog and digital cellular phone applications (AMPS, TACS, IS-54 and GSM) and 900 MHz cordless phone applications (CT1 and CT2) as well as spread spectrum receivers in the 902-928 MHz Industrial, Scientific and Medical (ISM) band. It is also available as part of a low-voltage TDMA IS-54 digital cellular chipset that combines all the necessary RF and IF functions (LNA/mixer, Fractional-N synthesizer, monolithic digital IF receiver and multifunction



The SA601 addresses a large and growing market for low-voltage RF receivers in everything from cellular phones to remote control units.

transmit modulator/synthesizer) in four chips.

The SA601 delivers high performance with low power consumption. Its LNA has a noise figure of 1.6 dB and a power gain of 11.5 dB at 900 MHz. The active mixer provides an additional 6 dB of conversion power gain with a noise figure of 10 dB at 900 MHz. LNA and mixer performance is exceptionally stable in fluctuating temperature and supply voltage (5.5 to 2.7 V) conditions, making the IC an excellent choice for mobile telephones.

Call 1-800-447-1500 Ext 1138
Europe: circle no. 44

9/94/US

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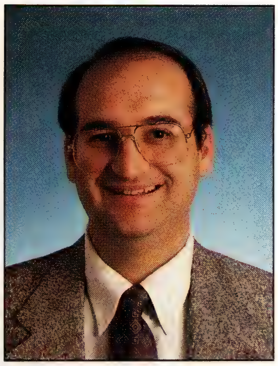

Twenty-five years

The universe arranged a giant fireworks show to commemorate the 25th anniversary of the Apollo 11 moon landing. A string of at least 21 rocky fragments, formerly known as Comet Shoemaker-Levy 9, bombarded Jupiter during the same four days (July 16 to 20) when Apollo 11 journeyed to the moon 25 years ago. We can see images of the incredible devastation wreaked upon Jupiter because of some terrific space hardware developed in the intervening years.

First, there's the Hubble Space Telescope, recently refurbished during a spectacular space-shuttle mission and eagerly trained on Jupiter. I watched a tape of the Hubble team as they viewed the first image returned by the telescope. The picture from Hubble showed several dark pixels marking the first impact spot on Jupiter. The team became ecstatic when they saw the assembled image, and several team members celebrated by swigging more than a little champagne on screen. Subsequent images of the impact results were even more exciting. Photos from the Keck telescope on Mauna Loa in Hawaii show a great blister raised in Jupiter's atmosphere by some of the fragments.

We can go back to the moon any time we want.

The comet fragments impacted Jupiter on the side of the planet facing away from the Earth, so we had to wait until the planet rotated the resulting wounds into view. We do, however, have another viewing platform in space. Space Probe Galileo is en route to Jupiter, and it can see the part of the planet being struck by the comet fragments. I have not seen the images as I write this editorial on the anniversary of the moon landing (July 20), but I'm sure the pictures will be spectacular. Meanwhile, impacts so far have already triggered huge electrical storms on Jupiter.

The point of all this is to say that we have indeed made significant progress in our space efforts since Apollo. True, we cannot return to the moon today, a situation many bitterly lament. I don't. We certainly retain the technology to go to the moon. All we need is the will to make the trip, and space has proven an irresistible lure to the curious. In the last few years, we've launched and fixed Hubble; we've flown Clementine, an econoprobe that has completely mapped the moon for the first time; and we've built and test-flown the DCX, an experimental single-stage-to-orbit rocket based on 1990s technology instead of Apollo's 1960s hardware or the space shuttle's 1970s hardware. We can go back to the moon any time we want. And we will.

STEVEN H LEIBSON
EDITOR-IN-CHIEF

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Editorial Achievement Award
1990 Certificate, Best Editorial
1990 Certificate, Best Series
1987, 1981 (2), 1978 (2), 1977, 1976, 1975

American Society of Business Press Editors Award
1994, 1991, 1990, 1988, 1983, 1981

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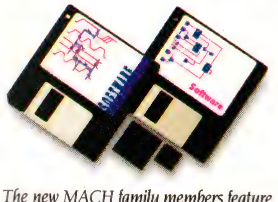

The new MACH family members feature speeds up to 7.5ns, while our new software tools include schematic design entry and timing simulation capabilities.

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Setting the Standard

Actual size

Upsetting the Standard

Actual size

MIXED-SIGNAL SIMULATORS NOW OFFER LANGUAGES THAT EXTEND THE DIGITAL DESIGN LANGUAGES OF VHDL AND VERILOG TO ANALOG DESIGN. THE OPTION TO USE ANALOG BEHAVIORAL DESCRIPTIONS SIMPLIFIES DESIGN AND INCREASES SIMULATION SPEED.

MIXED ANALOG-DIGITAL SIMULATION

DOUG CONNER, TECHNICAL EDITOR

THE MORE COMPLEX YOUR DESIGN, THE GREATER the chance that some parts of the system won't function properly together or function in all cases. Simulation provides designers with a way to test designs and verify a system before building the hardware.

The standards for modeling digital designs are VHDL, Verilog, and gate-level schematic design. For analog, the standard is Spice. Now, extensions to VHDL and Verilog extend the hardware description languages (HDLs) to analog design. Although the standards aren't finalized, products are emerging. You can describe your designs at any level from transistors through behavioral descriptions for both analog and digital. Simulating a mixed-signal system now offers many options.

Understanding mixed-signal simulation starts with first understanding the problems these simulators must face. How well a simulator works often depends on how effectively the manufacturer addresses the problems. Two key concerns characterize the mixed analog-digital simulation problem. The first is the speed of analog simulation: Transistor-level simulations run slowly in comparison with digital simulations with the same number of transistors. The problem centers around the greater number of equations that the simulator must evaluate for the same number of transistors compared to a digital simulator. Behavioral-level analog models can help speed up circuit simulation by reducing the number of equations that must be evaluated.

PHOTOGRAPH COURTESY CADENCE DESIGN SYSTEMS

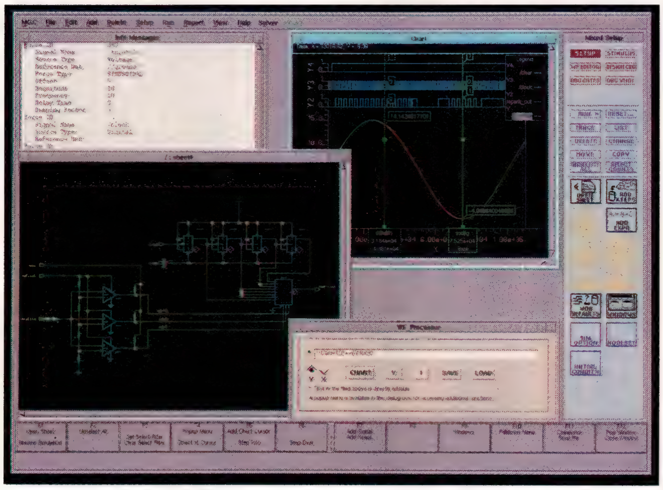
The second problem with mixed analog-digital simulation occurs when tying analog and digital simulators together. Although some simulators such as Analogy's Saber and MicroSim's PSpice provide a native mixed-signal capability, these simulators are aimed primarily at analog circuits with moderate numbers of digital gates. For mixed-signal circuits containing large numbers of digital gates, such as ASICs, standard digital simulators usually prove more effective. For this reason, most analog simulators intended for mixed-signal applications, even those with a native mixed-signal capability, provide interfaces that connect to the mainstream digital simulators.

Tying analog and digital simulators together presents two problems. First, the simulators must pass information back and forth, but they generally do not run with the same time increments. Digital simulators jump between state changes, usually referred to as events. In the digital domain, only state changes have significance; in the analog domain, time steps normally won't match the digital simulator. To pass data back and forth between the analog and digital simulators, manufacturers can synchronize the two simulators using different approaches.

A simple—but not necessarily efficient—method is to lock the two simulators' time steps together so that analog and digital simulators evaluate signals at every digital time step. This approach usually proves inefficient because the analog simulator needs to evaluate more time steps and slows the whole simulation.

Another approach typically used for simulation backplanes involves synchronizing the analog signal at some periodic rate. Depending on the periodic rate, the potential for analog-simulation error occurs if the period is too large. A too-small period results in slowed performance.

You could also let the two simulators run free and synchronize events only when data must be exchanged. This method works well except that one simulator may get ahead of the other, causing the analog simulator to require backtracking to a previous value. The simulator can backtrack either by using additional simulation or by using stored values from previous time increments.



Integrated mixed-signal simulators, such as Continuum from Mentor Graphics, let you view analog and digital waveforms on the same display, simplifying design verification.

Although any of the above methods will synchronize analog and digital simulators, the particular method used can affect the accuracy and simulation time. You should keep this in mind when you evaluate mixed-signal simulators.

Another problem in tying the analog and digital simulators together occurs when modeling the signals that interface between the analog and digital portions of the simulation. Although Boolean states work well for a digital simulator, an analog simulator requires more information to accurately model the signal. Treating an analog-to-digital transition as a comparator and a digital-to-analog transition as a switch works fine for a first cut at modeling a system. But for accurate results, you need more detailed models. The model may need to include output loading, nonlinear input parasitics, and input thresholds. The characteristics depend on the family of the digital circuits such as TTL, MOS, and ECL. Even within a particular family of digital devices, different devices may contain different characteristics, such as output drive.

The industry hasn't developed any standards for interfacing analog and digital models. So, when you evaluate different mixed analog-digital simulators, you may want to look into the details of how each handles the communication between the analog and digital simulators. Analogy, for example, developed a set of special models, called Hypermodels, for its Saber simulator that take care of the translation between analog and digital. The simulator automatically inserts the appropriate models between analog and digital parts.

Assuming you addressed synchronization and communication problems using a mixed-signal simulator, your greatest concerns remain specifying your design and simulation speed.

HDLs and top-down design methods, well known in the digital world, are also available in the analog design world. Lack of standards and lack of a pressing need has probably kept many designers from using them. Previously you could specify a system at a high level, but you needed to use a proprietary language designed for simulation, which lacked portability. Or, you needed to use a standard software language, such as C, which contained the flexibility but lacked models for analog simulation.

For the designer already comfortable with using Verilog or VHDL for creating descriptions of digital hardware, another language for analog behavioral descriptions with new syntax and other software-specific idiosyncrasies provides an unwanted burden. Although Spice reigned supreme for years as the analog modeling language, and will undoubtedly figure prominently for years to come, mixed-signal designers who work simultaneously in both the digital and analog world need something to simplify their work and make them more efficient.

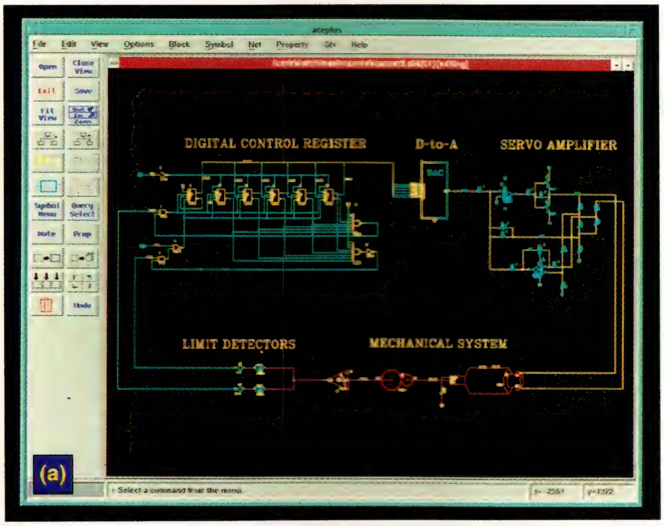
Proponents of VHDL and Verilog continue to battle for their cause, and because both languages have a popular foothold in the electronic design community, they will probably exist for some time. Consequently, any mixed-signal simulation language needs to work with both languages, unless the manufacturer wants to cut itself out of a significant segment of the electronic simulation market.

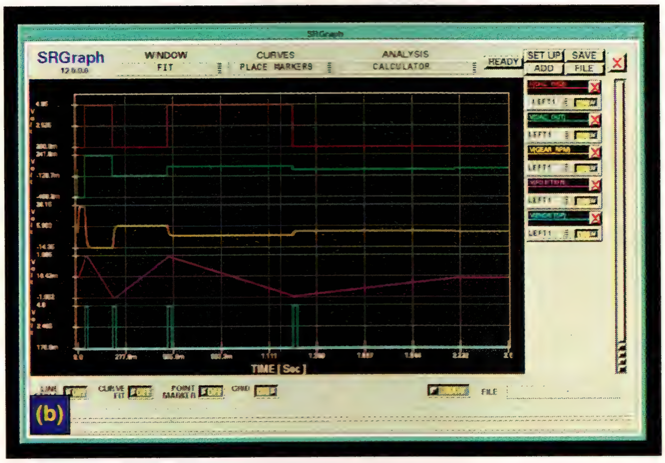
Although you could use analog

behavioral languages for some time, VHDL-A and Verilog-A are the first languages that attempt to bring analog and digital HDLs together. In the past, the languages used for the analog and digital portions of a design were either completely different or proprietary and focused toward the analog designer. Given a choice, you probably wouldn't write half a program in C and half in Fortran. The analog extensions to VHDL and Verilog help alleviate the multiple-language problem.

Top-down design provides a smooth path from initial specification through physical layout. Certainly, many spots in the path can trip you up. On the digital side, behavioral logic synthesis is just becoming available, but only for DSP and other specialized types of systems. You usually need to reduce your behavioral HDL design to the register transfer level (RTL) before logic-synthesis tools can implement the design. Timing problems may come back again to haunt you at the layout stage.

In the analog world, top-down design lacks even more steps. Presently, only a few specialized tools can synthesize analog designs from behavioral-level descriptions. These tools tend to exist for filter design and related functions. VHDL-A and Verilog-A set standards for hardware descriptions that may eventually result in the growth of analog synthesis tools. However, their utility is aimed at helping out with system specification and simulation. You'll need to eventually translate the behavioral hardware description into a functional circuit description suitable for implementation at the board or IC level.





The control circuit and mechanical system for a bar-code reader (a) combines gate-level, behavioral-level, transistor-level, control system, and mechanical models. Intergraph's Apex simulator (b) shows the analog and digital signals from simulation.

Having compatible HDLs for analog and digital provides a consistent method for specifying complex systems. With Verilog and VHDL as the leading standards for digital HDLs, the analog extensions should provide the easiest way for designers to describe the analog parts of a system for a combined analog-digital simulation.

Although Analogy, Anacad EES, and Mentor Graphics announced simulators compatible with the VHDL-A standard, Spectre HDL from Cadence remains the first analog simulation language to accept both VHDL-A and Verilog-A for mixed-signal simulation. The two languages are both proposed extensions to digital HDLs. VHDL-A, under development with a language reference manual (LRM) to define the standard, is expected around the end of 1994. Cadence submitted Verilog-A as a proposed LRM to the Open Verilog International (OVI) organization. Changes to the languages will undoubtedly occur since neither language exists as a true standard. However, all of the vendors involved maintain they will continue to upgrade the tools to maintain compliance as the languages evolve.

Maintaining compatibility with a language that does not contain formal definition may sound risky, but the risk probably isn't too great. Standard syntax conventions for VHDL and Verilog remain well established and the companies can adhere to these. Although changes to the functions may present a problem for models, adding new functions to simulators should be fairly easy. Depending on how great the changes are as the languages evolve, users may need to spend some time upgrading models to maintain compatibility with an evolving standard.

Although it sounds risky to use tools trying to meet a yet-undefined standard, the benefits outweigh the risks. First, the HDLs speed up design by letting you specify the design at a higher level. Digital HDLs show significant time savings on large designs, and designers of analog systems can expect a time savings, also.

Second, the behavioral models speed up simulation. According to Cadence, Spectre HDL can speed up simulation by a factor of 10 to 100× or more depending on the level of behavioral modeling used. Some of the benchmarks Cadence ran on designs show simulation time dropping from hours to minutes or even seconds. These reductions in simulation time can save a significant amount of time in the product development phase.

Although an analog HDL design can run more than 100× faster than an equivalent Spice simulation, it may not provide the detail you need. Although you can create an HDL model that simulates just as accurately as a Spice model, most models probably won't be taken to that level of detail. At some time during the verification of a design,

(continued on pg 44)

REPRESENTATIVE MIXED-A/D SIMULATORS

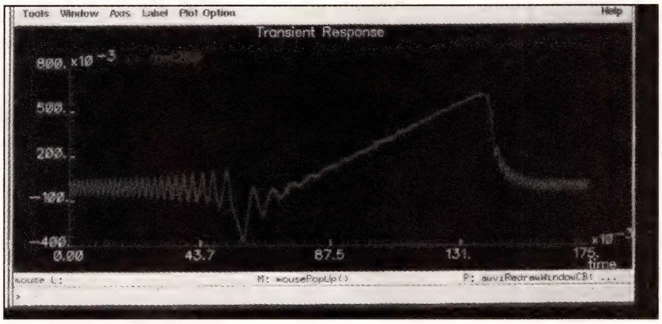
Company	Product	Price	Simulation capability	Computer and operating system
Altium/IBM Circle No. 301	AUSSIM	$25,000	Digital and mixed-signal	Workstations
	SpecSim	$50,000	Analog	Workstations
Anacad EES Circle No. 302	VHDeLDO	$36,000	Mixed A/D	Workstations
Analogy Circle No. 303	Saber	$20,000	Mixed A/D	Workstations
AT&T Circle No. 304	ATTSIM	$65,000 to $75,000	Mixed A/D	Workstations
Cadence Circle No. 305	Spectre	$30,000	Spice compatible	Workstations
	Spectre HDL	$10,000	Analog behavioral modeling	Workstations
	Spice+	$5000	Analog	Workstations
Compass Design Automation Circle No. 306	Navigator, mixed-signal design option	$40,000	Mixed A/D	Workstations
Contec Microelectronics USA Circle No. 307	ContecSpice	$5000	Mixed A/D	Workstations and PCs
Dolphin Integration Circle No. 308	Smash Standard	$6500	Mixed A/D	Workstations, Windows, Macintosh
Epic Design Technology Circle No. 309	Timemill	$69,640	Mixed A/D	Workstations
	Powermill	$77,100	Mixed A/D	Workstations
Intergraph Circle No. 310	Apex	$10,000	Mixed A/D	Workstations
	AdvanSIM-1076	$10,500	Digital	Workstations
Intusoft Circle No. 311	ICAP/4Windows	$2595	Mixed A/D	Windows , Windows NT, Macintosh
Mentor Graphics Circle No. 312	Endeavor	$26,900	Mixed-signal simulation for custom ICs	Workstations
	HSPICE	$20,000	Analog	Workstations
	Continuum	$65,000	Mixed A/D	Workstations
	Accusim II (Eldo)	$22,000	Analog	Workstations
	Lsim	$49,500	Digital	Workstations
Meta-Software Circle No. 313	HSpice	$3500 to $90,000	Analog	Workstations, PCs, Cray
MircroSim Circle No. 314	PSpice A/D	$5450 to $15,900	Mixed A/D	Workstations and PCs
Tanner Research Circle No. 315	T-Spice Pro	$1245 to $3650	Analog	Workstations and PCs
Viewlogic Circle No. 316	Mixed-Signal Designer, HSpice	$48,500 to $53,500	Mixed A/D	Workstations and PCs

Transistor	Behavioral (digital)	Behavioral (analog)	Languages supported by simulator	Notes
	Modeling levels supported			
	Yes		VHDL, C	Mixed-event and cycle-based simulation with limited analog support.
Yes	Optional		Spice	Simulator lets you trade off simulation accuracy against run time. Interface to AUSSIM optional.
Yes	Yes	Yes	VHDL, C, Verilog HDL-A, Spice	VHDL-based A/D simulation in one simulation environment.
Yes	Yes	Yes	Mast, C, Fortran, Spice	MAST HDL for analog and mixed-signal modeling. Digital simulator interfaces available.
Yes	Yes	Yes	VHDL, Spice, C	
Yes	Optional		Spice	Digital simulator optional.
Yes	Optional	Yes	VHDL, Verilog	Requires the Spectre simulator. Digital simulator optional.
Yes	Optional		Spice	Digital simulator optional.
Yes	Yes	Yes	Spice, MainSail	Uses Anacad EES Eldo analog simulator.
Yes	Yes	Yes	Spice	Simulates mixed-signal, signal integrity, EMI, EMC, VLSI, RF, and microwave designs.
Yes	Yes	Yes	C	
Yes	Optional		C	Verilog interface optional.
Yes	Optional	Yes	C, Verilog	Verilog interface optional.
Yes		Yes	Spice, Diablo	Diablo is a behavioral language based on C.
	Yes		VHDL, C, DSPARC	For simulating more complex system, cosimulate with the analog simulator.
Yes	Yes	Yes	Spice2, Spice3, C, Proprietary Boolean and digital languages.	General purpose and high frequency up through RF and microwave. The system includes over 5000 models.
Yes	Yes	Yes		
Yes			Spice	
Yes	Yes	Yes	VHDL, HDL-A, C, Spice.	Combination of Accusim II and Quicksim II.
Yes		Yes	HDL-A, C, Spice	
Yes	Yes		VHDL, C, Spice	
Yes			Spice	Requires interface software for mixed-signal simulation.
Yes		Yes	Spice	Native mixed-A/D simulator.
Yes			Spice, C	Table-based model evaluations for improved simulation speed.
Yes	Yes	Yes	VHDL, Verilog, C, Spice	Simulation backplane option provides cosimulation with 10 different simulators. Support for LSim, Zycad, Saber, HSpice, and PSpice.

To get information from all the manufacturers in this table, Circle No. 317

MIXED ANALOG-DIGITAL SIMULATION

you may want the detail provided by a transistor-level Spice simulation, and you may end up running the simulation for hours to get the final verification. At the early stages of a design, you can often find and correct many errors or simply perform system design tradeoffs while working with simpler behavioral models of the system.



This phase lock loop was modeled using Spectra HDL. The photo shows the PLL output as the input frequency is swept. The output, initially out of lock, goes into lock and then goes out of lock. A multiple-hour simulation at the device level, the simulation takes only seconds at the behavioral level.

The situation remains somewhat analogous to finding functional design problems in a digital design with a cycle-based simulator. In a synchronous design, the cycle-based simulator ignores timing issues and assumes the functional logic reaches the next logic state within the allotted time. You can hammer out the functional design problems first before attacking the timing issues.

In the analog case, you define the behavior of a circuit with behavioral models before descending into the detailed behavior. In essence, you try to solve the system-level concern of specifying the design of a system that does what you want before designing the implementation details. While the concept is generally sound, you may run into problems.

In the digital case, the cycle-based simulation initially lets you ignore timing, but eventually you must face timing issues. When you bring in the reality of timing issues, you may find that your system design won't work. You need to add pipelining or other major changes to the architecture to satisfy the timing.

In going from a simple analog behavioral simulation to a more refined behavioral simulation or a transistor-level simulation, you may also find that some of the simplifications you made prevent the system from working. The problem could result from input capacitance, temperature drift, or any number of problems that you may have ignored in your behavioral model.

As always, whether you model a circuit in Spice at the transistor level or use behavioral-level models, the engineering judgment you use in creating the models and running the simulation determines whether the simulation accurately models the system. In addition, you want to explore all the potential problems.

In using simulators that accept the VHDL-A or Verilog-A languages, you don't have to give up any Spice models. All the simulators mentioned accept Spice models along with the HDL models. Spectre HDL lets you mix all three types of models in the same system simulation to give you the greatest flexibility.

To take advantage of the simulation speed potential of behavioral models, however, you need to model all or most of your system with them. Although you can translate a Spice model into a behavioral model manually, Cadence offers the Resolve optimizer to help automate the process. The optimizer helps you refine the behavioral model to accurately reflect the results of the Spice model simulation within 1 to 2%. Once you've optimized the behavioral model, you can use it in a system simulation and obtain much faster simulations.

MANUFACTURERS OF MIXED ANALOG-DIGITAL SIMULATORS

For free information on the mixed analog-digital simulation products discussed in this article, circle the appropriate numbers on the postage-paid Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you read about their products in EDN.

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AT&T Design Automation
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MIXED ANALOG-DIGITAL SIMULATION

If you are designing any parts of your system from the bottom-up, you may want to simulate the parts at the transistor level using Spice. Once you've developed that circuit, you can change it into a behavioral model for system simulation.

You can perform behavioral-level modeling at more than one level. When creating the initial design of a system you may opt for behavioral models that encompass large blocks of the system. You may choose to model the system with very idealized behavior. You can easily model idealized comparators, op amps, gain blocks, etc. Once you've blocked out an entire system this way and verified the system at a high level, you can start refining the system, perhaps breaking those large system blocks into smaller blocks. Or, you could just refine the behavior of the large blocks to accurately model the true instead of ideal behavior of the system.

By using this top-down approach to developing and modeling your system, you can save simulation time. The simpler high-level models run quickly. You may be able to use the fast, high-level behavioral models throughout most of a system and use low-level behavioral or transistor-level models for the block you are attempting to verify. This gives you a high-fidelity model of the system block you are verifying and a faster (but still reasonably accurate) model for the rest of the system. You'll need to decide how much detail you need for different blocks to give you an accurate model of the system.

Because transistor-level analog simulation is considerably slower than digital simulation, mixed analog-digital circuits with only 5% of the transistors used for analog circuits will still spend most of the total simulation time evaluating the analog portion of the circuit. Behavioral modeling with analog HDLs helps speed up mixed-signal simulations, even when the analog portion of the design appears insignificant.

Along with analog simulation, many of the simulation tools provide support for nonelectrical disciplines, too. Analogy's Saber product pioneered analog behavioral modeling and multidiscipline simulation. The company still contains the widest library of functions available for mechanical, hydraulic, and other nonelectrical disciplines that you can include in your system simulation. With the wide access to mathematical functions, analog behavioral languages should make it easy for you to model nonelectrical behavior. Modeling nonelectrical systems is not limited to analog behavioral languages, either. Some of the transistor-level Spice simulators can simulate a nonelectrical system. However, the capabilities and ease with which you can model a nonelectrical system vary.

LOOKING AHEAD

Analog extensions to the Verilog and VHDL standards are almost here, and simulation products based on preliminary versions are already out. The HDLs pave the way for analog circuit synthesis, but don't hold your breath. Analog synthesis remains a few years away. For the near future, new products bring faster analog and mixed-signal simulation.

It's important to remember that, although every mixed-signal designer needs to work with analog design issues, not every analog designer is involved with digital design. Those designers who work mostly in analog and never need a digital HDL may not need the analog extensions of VHDL or Verilog. They may find Spice and possibly proprietary analog behavioral modeling languages meet their needs. The designer most likely to benefit from the new mixed-signal behavioral languages is the designer of large, mixed-signal systems, particularly those systems using mixed-signal ASICs.

Many of the mixed-signal simulation tools shown in **Table 1** offer features to help in simulating large systems. AT&T's ATTSIM is a single simulator for mixed-signal ICs and has the capacity for complete board-level system simulation. The simulator automatically partitions the analog section into multiple blocks and lets you use different time steps with each block to perform long simulation on circuits with multiple time constants.

Epic's Timemill and Powermill simulation tools, intended specifically for simulation of CMOS and BiCMOS circuits, perform accurate simulation of timing and static and dynamic power characteristics. The simulator provides direct simulation of transistor-level mixed-signal circuits. Because the tools are specialized for CMOS and BiCMOS circuits, they can run about 100× faster than Spice while yielding results that fall within 5% of those results produced by Spice. The simulators will accept over 2,000,000 transistors, and they can cosimulate with Verilog.

IBM offers several products aimed at large mixed-signal IC simulation. The company's AUSSIM simulator, primarily a VHDL simulator, contains some limited analog capability. The simulator models and simulates in native compiled code. For complete analog simulation, the company offers SpecSim. This transistor-level simulator is tailored for large digital and memory circuits with a capacity of over 100,000 transistors. The simulator lets you trade accuracy for speed. The speed-accuracy tradeoff can apply to a complete simulation or on a block-by-block basis, letting you simulate one block of a circuit accurately while using lower accuracy and higher speed for the other circuit blocks. The company claims SpecSim runs 20 to 200× faster than traditional simulators with comparable accuracy. A simulation backplane product called SimMatrix lets you tie the AUSSIM and SpecSim simulators together for mixed-signal systems.

Tanner's T-Spice focuses on ASIC applications. The simulator uses table-based model evaluations to provide faster speed in circuit simulation. The simulator contains the capacity for full chips with over 200,000 elements. EDN

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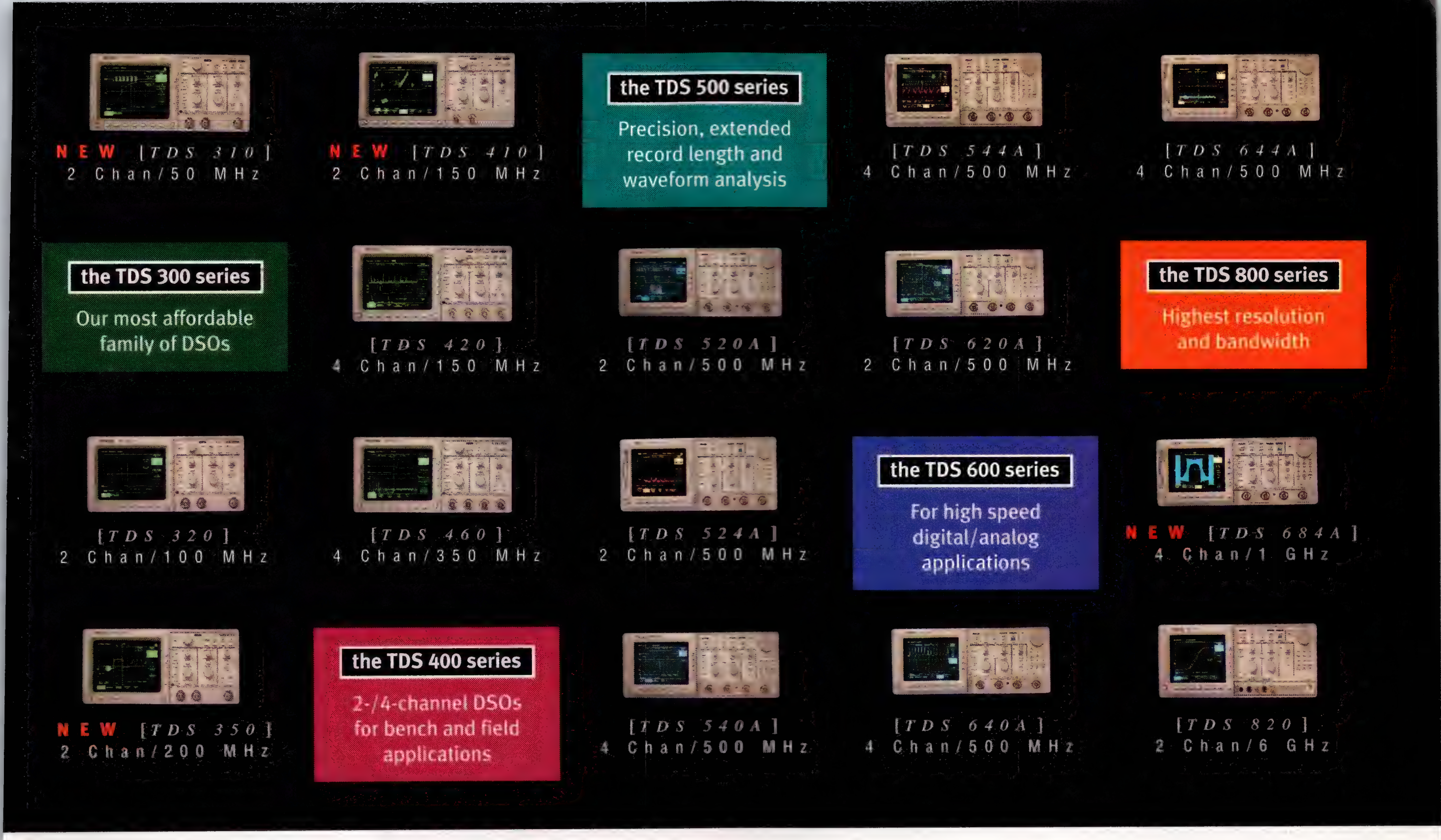

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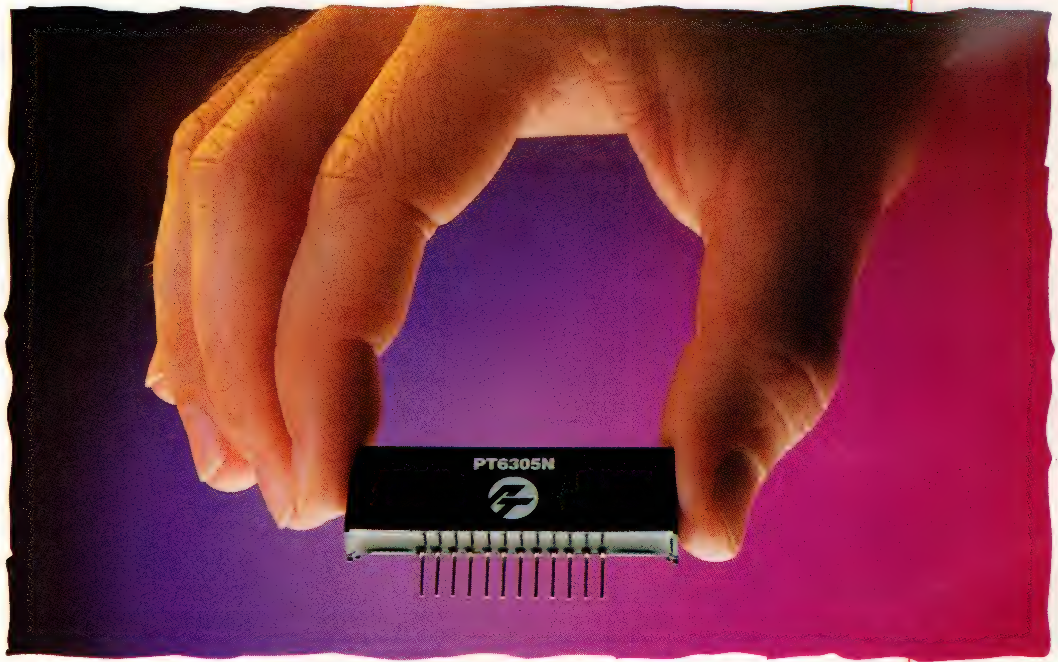

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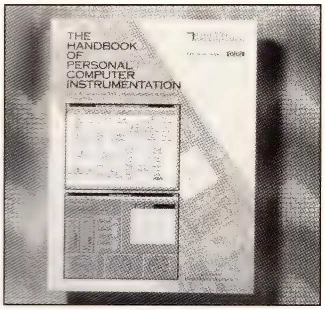

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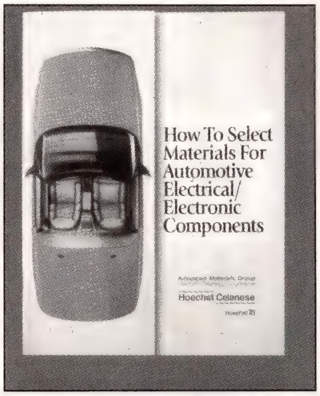
Catalog covers five product lines. A 64-pg color catalog contains specifications and selection guides for data-conversion components, modular dc/dc converters, digital panel meters, analog boards for the PC/AT and EISA buses, and analog boards for the VMEbus. **Datel Inc**, Mansfield, MA. **Circle No. 398**

Data book features STD 32 computers. This 464-pg book provides features, specifications, and ordering information for the vendor's STD 32 computers. The data book lists support services and offers selection guides. **Ziatech Corp**, San Luis Obispo, CA. **Circle No. 399**

Catalog features manufacturing and repair products. This 212-pg catalog describes the vendor's electronic manufacturing and repair products. The publication lists products for static control, soldering, pc-board materials, EMI/RFI shielding, thermal management, sleeving, and insulating. **Electrical Insulation Suppliers**, Hillside, IL. **Circle No. 400**

Journal highlights signal-processing circuits, systems, and software. *Analog Dialogue* (Volume 28-1) discusses the vendor's TMP01 single-chip, temperature sensor/setpoint controller, the 1B60 intelligent digitizing signal conditioner, and the AD2S100 analog vector processor for motor control. The free publication also includes application articles on using IC-voltage references and sigma-delta-architecture A/D converters. **Analog Devices**, Norwood, MA. **Circle No. 401**



Selection guide for choosing plastics for automotive electrical and electronic components. *How to Select Material for Automotive Electrical/Electronic Components* describes seven engineering and high-performance thermoplastics for use in automotive electrical and electronic components. The guide features solutions to the demand that today's auto environment places on E/E systems and components. The brochure also describes the use of resins to solve engineering problems in the design and manufacturing of ignition and power-distribution systems, sensors, switches, and actuators. **Hoechst Celanese**, Chatham, NJ. **Circle No. 402**

Selection guide covers force-balance servo accelerometers and inclinonometers. This 24-pg catalog features the operating modes, engineering data, and model variations for force-balance sensors and inclinometers. The brochure details low-cost, general-purpose, high-performance, triaxial, and high-temperature sensors. **Columbia Research Laboratories Inc**, Woodlyn, PA. **Circle No. 403**

Brochure describes self-locking fasteners. This free brochure details self-locking fasteners, explains how they work, and details applications and design solutions. The handbook provides design information for engineers who work with threaded fasteners. **Long-Lok Fasteners Corp**, Cincinnati, OH. **Circle No. 404**

Newsletter aims at OEM power and magnetic specifiers. *Current Events* discusses pertinent design, regulatory, application, and manufacturing concerns of OEM power and magnetic specifiers of 50/60-Hz transformers from 1 VA to 10 kVA. **Signal Transformer Co**, Inwood, NY. **Circle No. 405**

Brochure outlines components. This brochure describes the vendor's high-performance EMI/RFI-sup-

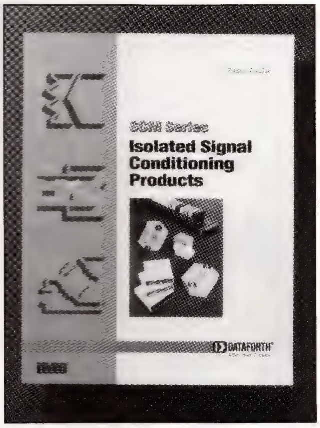
pression devices, relays, and transformers. **Eichhoff Electronics Inc**, Warwick, RI.
Circle No. 406

Catalog features semi-rigid products. This 68-pg catalog details a line of semi-rigid cables, resonators, and delay lines. The catalog also describes MIL-SPEC, very-low-loss, low-impedence, high-temperature, and triaxial cables. **Micro-Coax**, Collegeville, PA. **Circle No. 407**

Semiconductor product guide. This selector guide features power semiconductors, including transistor, rectifier, and thyristor modules and discrete high- and low-power products. Selector tables provide parametric data, number systems, and package outlines for each product. **Powerex Inc**, Youngwood, PA.
Circle No. 408

Brochure details bearing selection and graphics package. This four-pg brochure highlights the vendor's details bearing dimensions, load ratings, calculation factors, speed ratings, and abutment dimensions. The publication also covers a graphics program that lets users access a library of bearing drawings. Users can import these drawings directly into a CAD program or other documents. **SKF USA Inc**, King of Prussia, PA.
Circle No. 409

Catalog features IEEE-488 and notebook-PC-based data-acquisition products. This free 152-pg catalog describes hardware and software products for IEEE-488 control and notebook-PC-based data acquisition. The coverage of IEEE-488 products includes instrument controllers, bus analyzers, bus extenders, serial-to-IEEE-488 converters, and IEEE-488 data-acquisition instruments. **IOtech Inc**, Cleveland, OH.
Circle No. 410



Catalog features analog and digital I/O modules and accessories. This 100-pg catalog contains descriptions, specifications, and application notes for a line of analog and digital I/O modules and accessories. The publication contains detailed technical guides for Dataforth's three SCM product families: SCM5B isolated analog I/O products, SCM9B isolated intelligent I/O products, and SCMD digital I/O products. **Dataforth Corp**, Tucson, AZ. **Circle No. 411**

Power-supply reference book. *Considerations When Specifying Switchmode Power Supplies* covers a variety of topics, including reliability, agency approvals, EMC, power-factor correction, specification writing, strife testing, custom vs standard, vendor selection, thermal management, and power density. The 32-pg guide also contains appendices for major safety and quality agencies, mechanical and electrical considerations, and a bibliography. **MicroEnergy Inc**, Longwood, FL. **Circle No. 412**

CIRCLE NO. 84

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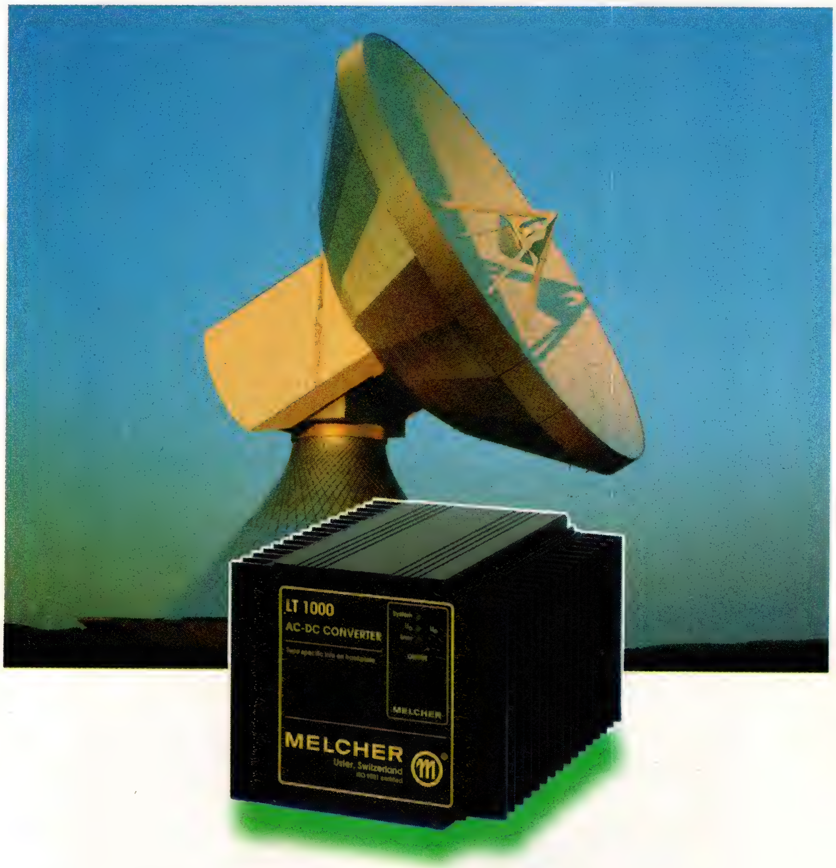

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CIRCLE NO. 136

EASY-TO-USE FLASH-MEMORY MODULES EMULATE DISK DRIVES

GARY LEGG, EXECUTIVE EDITOR

Because more and more flash-memory modules look just like familiar disk drives to your system, designing in fast and rugged mass storage has never been simpler.

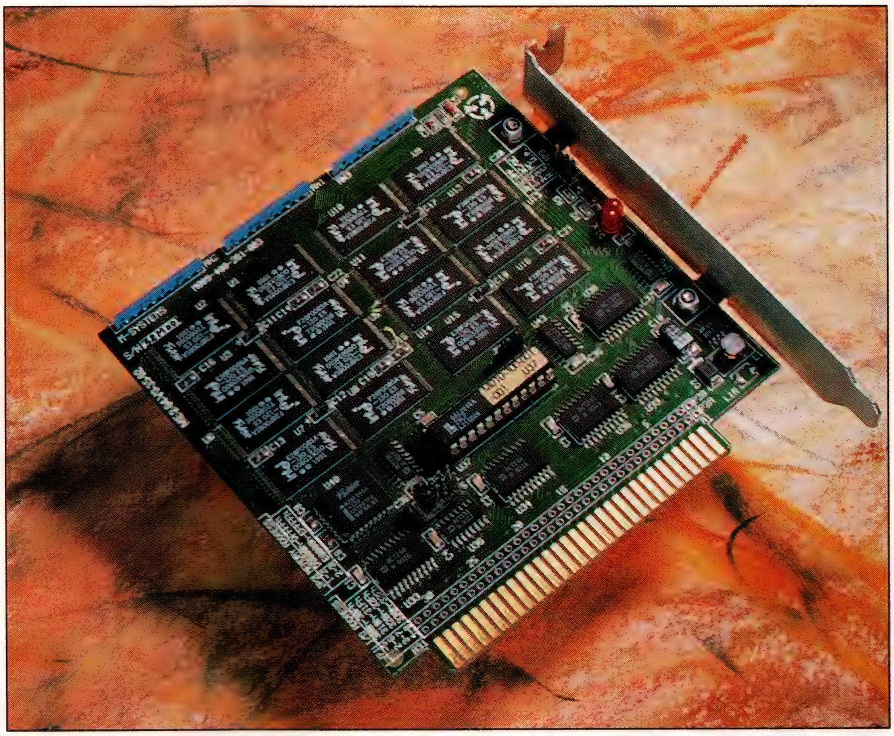
Companies promoting the use of flash memory in mass-storage applications seem to have made an interesting discovery: To convince customers to use flash instead of a disk drive, make the flash *look* like a disk drive. Increasingly, new flash storage products incorporate a hardware controller that emulates a disk drive's system interface.

No longer the domain of niche companies, disk-emulation flash storage is now in the mainstream. IBM, Intel, and several disk-drive manufacturers all have products in the form of PCMCIA-ATA (AT Attachment) cards, which include a standard IDE disk interface. Big PCMCIA vendors—Epson, for example—are adding ATA cards to their lines. Only a year or so ago, disk-emulation flash was the realm only of SunDisk and one or two competitors.

If it looks like a disk...

With a familiar disk interface, flash products are easy to design into a system and easy to use. They have little impact on system software, and they allow application programs to work without modification. The main drawback is the added cost of the interface—around $20 to $30 for a PCMCIA card.

Falling prices for flash-memory ICs offset the added cost of disk emulation. Intel's 5-Mbyte PCMCIA-ATA card now sells for $270 (1000), down from $310 earlier this year. SunDisk's recent 10 to 30% price cuts will probably result in retail prices of $179 to $199 for an ATA card that stores 1.8 Mbytes (3.6 Mbytes with data-compression software). That's as cheap as a disk drive, although disk drives have much higher capacity.



The PC Flash Disk from M-Systems plugs into any ISA or EISA bus and provides as much as 32 Mbytes of storage. Embedded flash-file-system software makes the board's flash memory appear to the system as a disk drive. An onboard expansion BIOS eliminates the need for any software installation.

FLASH DISK

However, if you need only about 5 Mbytes or less, then flash is a better buy.

The variety of new disk-emulation products (**Table 1**) is impressive. In addition to PCMCIA cards, flash "disks" are available as PC plug-in boards, rugged cartridges, and even single ICs. Even physical replacements for 3.5- and 2.5-in. hard drives are available, although their high capacities make them expensive. For example, you can figure on a price of $5000 to $6000 for 100 Mbytes.

The proliferation of hardware-based disk emulation indicates a shift away from an alternative approach. The other approach implements disk emulation (or at least flash-memory file handling) in system-resident flash-file-system (FFS) software. Microsoft's (Redmond, WA) FFS and M-Systems' TrueFFS are the best known flash-file systems; others are available from SCM Microsystem (Martinsried, Germany and Santa Clara, CA) and Datalight (Arlington, WA).

The main purpose of FFS software is to work around flash memory's limitations as a mass-storage medium. For example, the software must accommodate flash's erase-before-write requirement, long erase times, lack of byte-by-byte erasability, and limited endurance. (Flash cells can accommodate only a certain number of erase/write cycles and still work reliably.) Hardware-based disk emulation performs the same tasks; it simply moves flash control from the system to the storage devices themselves (**Fig 1**).

Jumping on the bandwagon

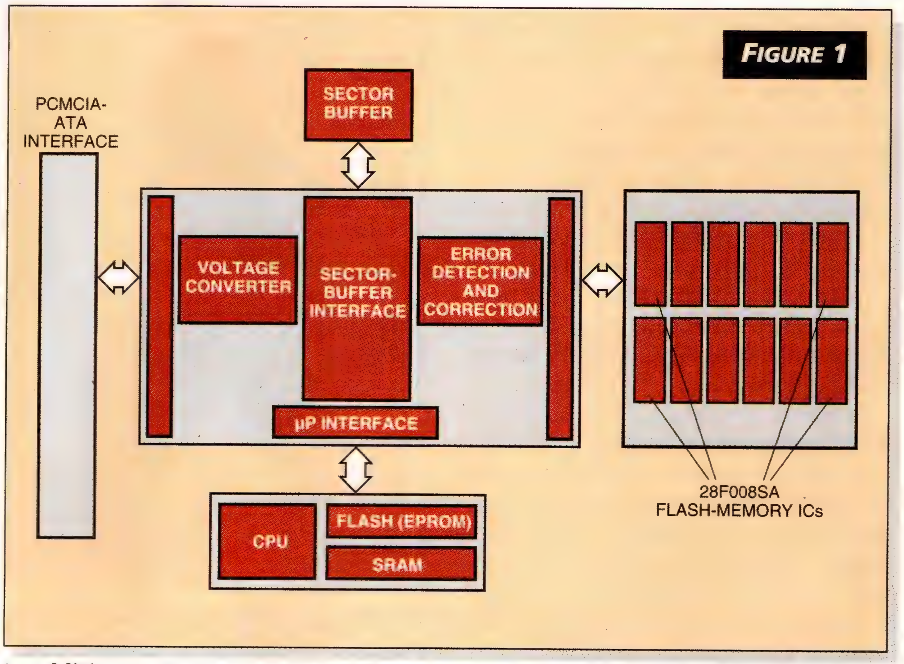
Significantly, some of the latest disk-emulation products come from companies that champion FFS software. Intel, for example, is a longtime backer of Microsoft's FFS. M-Systems recently introduced hardware-based disk-emulation flash products in a variety of forms. Eurom, an M-Systems subsidiary, is marketing a single-chip flash disk that replaces a system's BIOS ROM.

System-resident FFS software is still a viable alternative to disk emulation, however, and may even be the long-term preferred approach. Being software, it's potentially cheaper, and it usually provides somewhat faster reading and writing. Eventually, its backers say, FFS software will simply be an invisible, but effective, part of most operating systems.

For now, though, flash software's lack of a large installed base gives impetus to storage products that provide their own flash control. Only new sub-notebook computers are likely to incor-

(Continued on pg 56)

Disk-emulating PCMCIA-ATA flash cards, such as this one from SunDisk, have capacities as high as 40 Mbytes. Data compression can effectively double the capacity.



In addition to flash memory, a PCMCIA-ATA card, like this one from Intel, includes a controller, firmware, and interface logic to make the device emulate a disk drive.

CIRCLE NO. 89

TABLE 1—REPRESENTATIVE FLASH-MEMORY STORAGE DEVICES

Manufacturer	Form factor	Interface	Disk emulation	Capacity (Mbytes)	Price
Advanced Micro Devices Sunnyvale, CA (800) 222-9323 **Circle No. 366**	PCMCIA card	PCMCIA	No	1 to 10	$75 to $385 (1000)
American Microsystems Inc Pocatello, ID, (208) 234-6661 **Circle No. 367**	PCMCIA card	PCMCIA	No	0.25 to 4	NA
Cardwell International Corp Folsom, CA (916) 985-1880 **Circle No. 368**	PCMCIA card	PCMCIA	No	0.5 to 16	$139 to $309
Curtis Inc St Paul, MN (612) 631-9512 **Circle No. 369**	PC plug-in board	ISA bus	Yes	1 to 40	NA
Dovatron Longmont, CO (800) 848-1198 **Circle No. 370**	Miniature board	ESP	Yes	1 to 16	$275 to $1314 (100)
Epson America Inc Torrance, CA (800) 289-3776 **Circle No. 371**	PCMCIA card	PCMCIA-ATA	Yes	2.5 to 20	$399 to $1499
Eurom Inc Tel Aviv, Israel 972-3-490920 **Circle No. 372** or Santa Clara, CA (408) 748-9995 **Circle No. 373**	Multichip module	BIOS ROM socket	Yes	1 to 16	$119 to $209 (100)
Fujitsu Microelectronics Inc San Jose, CA (408) 922-9000 **Circle No. 374**	PCMCIA card	PCMCIA	No	0.25 to 16	NA
Hitachi America Ltd Brisbane, CA (800) 285-1601, ext 16 **Circle No. 375**	PCMCIA card	PCMCIA	No	2 to 10	From $230 (500)
IBM Microelectronics Hopewell Junction, NY (800) 426-0181 **Circle No. 376**	PCMCIA card PCMCIA card	PCMCIA PCMCIA-ATA	No Yes	4 to 16 3 to 40	$216 to $709 (1000) NA
Intel Corp Santa Clara, CA (800) 879-4683 **Circle No. 377**	PCMCIA card PCMCIA card	PCMCIA PCMCIA-ATA	No Yes	2 to 40 5 to 10	$91 to $1543 (1000) $270 to $408 (1000)
Maxtor Corp San Jose, CA (408) 432-1700 **Circle No. 378**	PCMCIA card	PCMCIA	Yes	2 to 20	NA
Memtech Sunnyvale, CA (800) 445-5511 **Circle No. 379**	PC plug-in board 3.5-in. drive	ISA/EISA bus SCSI-2	Yes Yes	2 to 32 24 to 432	$2584 (32 Mbytes, 100) $50 to $60/Mbyte
M-Systems Fremont, CA (510) 505-9081 **Circle No. 380**	PC plug-in board Small board 5.25-in. drive Cartridge Rugged module	ISA bus PC/104 SCSI-2 ISA bus Serial	Yes Yes Yes Yes Yes	1 to 32 2 to 4 2 to 320 1 to 48 2 to 48	From $139 (100) From $118 (100) NA NA NA
Quantum Corp Milpitas, CA (408) 894-5088 **Circle No. 381**	PCMCIA card	PCMCIA	Yes	1 to 10	$90 to $520
RadiSys Corp Beaverton, OR (800) 950-0044 **Circle No. 382**	Small board (embedded)	EXMbus	Yes	10 to 40	$1744 to $4470
Raymond Engineering Middletown, CT (203) 632-4334 **Circle No. 383**	PCMCIA card	PCMCIA-ATA	Yes	1.8 to 40	NA
Seagate Technology Scotts Valley, CA (408) 438-6550 **Circle No. 384**	PCMCIA card	PCMCIA-ATA	Yes	1 to 40	NA
Silicon Storage Technology Sunnyvale, CA, (408) 735-9110 **Circle No. 385**	PCMCIA card	PCMCIA	Yes	1 to 14	NA
Smart Modular Technologies Fremont, CA (510) 623-1231 **Circle No. 386**	PCMCIA card	PCMCIA	No	2 to 4	$180 to $230
SunDisk Corp Santa Clara, CA (408) 562-0500 **Circle No. 387**	PCMCIA card	PCMCIA-ATA	Yes	1 to 40	$100 to $2000
Targa Electronic Systems Inc San Ramon, CA (510) 277-0188 **Circle No. 388**	Cartridge 3.5-in. drive	IDE, SCSI, or serial IDE, SCSI, or SCSI-2	Yes Yes	5 to 40 80 to 500	From $995 NA

To get information from all the manufacturers in this table, Circle No. 389

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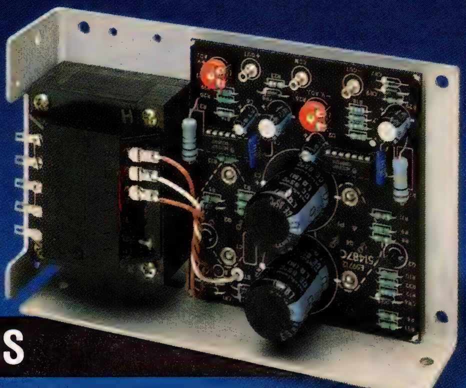

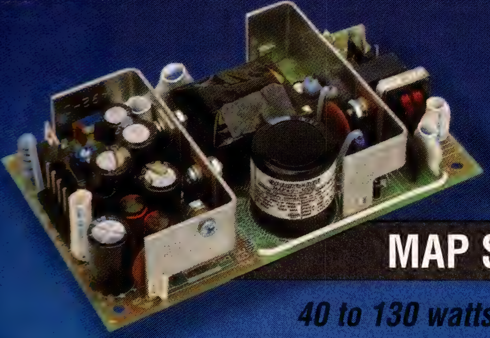

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CIRCLE NO. 95

porate FFS, and that software comprises incompatible products from various vendors. Few desktop computers have any flash software at all.

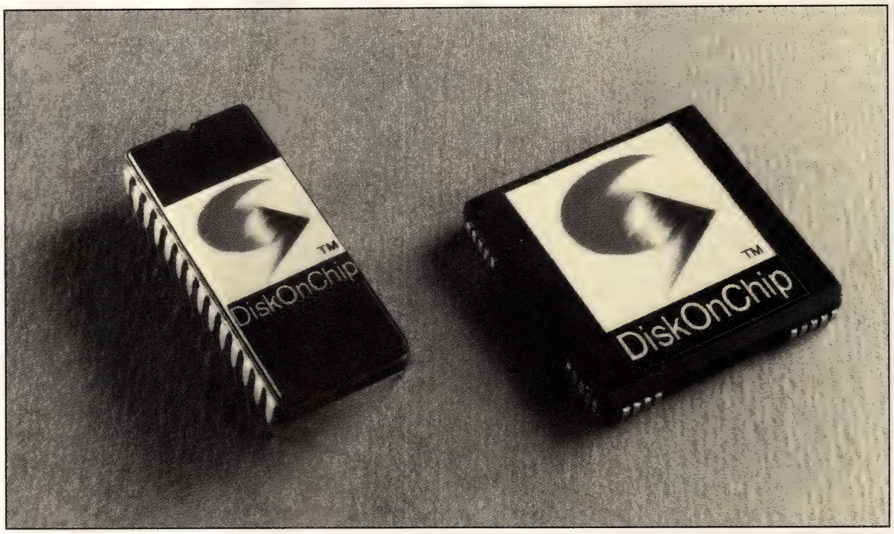
Even so, plenty of flash products still forgo disk emulation. Intel and IBM, for example, sell flash cards with and without disk emulation. Many other companies—for now, at least—are staying with memory-only cards. Fujitsu, for example, has an ATA prototype card, but is looking at market conditions before deciding whether to market it.

Emulating a disk drive isn't necessary or even desirable in all applications, and the additional cost of emulation is often prohibitive. Adding $20 or $30 is one thing in a 10-Mbyte device that sells for several hundred dollars; in a cheaper card with much lower capacity, it's something else. And most applications that use flash still require fairly low storage. According to Dave Roeckel, marketing manager of Dovatron, most flash-based embedded-systems applications use 1 to 4 Mbytes.

For the most part, disk-emulation flash and conventional flash serve separate markets. George Robillard, Fujitsu's director of memory products, notes that his company's conventional flash cards find use in industrial and embedded applications, primarily storing program code that needs only occasional updating. Disk-emulation cards, Robillard says, are useful primarily in small portable computers for storing data files that need more frequent updating.

A few distinguishing technical features further define applications for the two types of flash storage, especially for PCMCIA cards. Memory-only cards offer the possibility of program execution in place (XIP); in contrast, a program stored on an ATA card must load into system memory before execution. You can boot from an ATA card, however, and run common disk-utility and data-compression software. Depending on the FFS software, you may be able to do those things with a memory-only card. The key is using software that emulates disk operations at the sector level, such as M-Systems's TrueFFS and Datalight's CardTrick.

With or without hardware-implemented disk emulation, flash-storage devices usually outperform disk drives (**Ref 1**). Without a disk's track-seek and rotational latencies, flash provides almost instantaneous data access. Flash is somewhat slow in writing, but its read rates are comparable to disk's, and most application programs read data far more often than they write. Consequently, poor write performance isn't usually a problem with flash and flash's short access time usually hides that performance. Flash also consumes less power and is more rugged than a disk drive.



DiskOnChip from Eurom holds as much as 16 Mbytes of data in flash memory. The multichip module also contains a replacement BIOS, hardware, and firmware that make the device emulate a conventional disk drive.

With advances in flash-IC technology, even slow write rates are improving. For example, Intel's 28F016SA 16-Mbit flash chips include two 256-byte RAM buffers that increase the sustained write rate to 430 kbytes/sec—about four times the rate of earlier, 4-Mbit chips. When you use the chips in ATA cards, interleaving word writes to the two buffers and among the chips can increase the rate to 850 kbytes/sec—nearly double the component rate. For now, however, Intel's ATA cards still use older, 8-Mbit flash chips.

Toshiba's (Irvine, CA) NAND EEPROM flash chips address the write problem by featuring both fast erase and write times. Earlier flash ICs for disk-emulation applications—notably those from SunDisk and SST (Sunnyvale, CA)—had boosted erase speed. The Toshiba, SST, and SunDisk chips aren't byte-addressable, like traditional flash ICs. However, their use in disk emulation, with 512-byte sectors, makes byte-by-byte access unnecessary.

In some flash chips, an "erase suspend/resume" feature minimizes the performance effects of erasing. Flash ICs from AMD, Intel, and Toshiba, for example, temporarily suspend an erase operation in one erase block to allow a read or a write in another block. Given that an erase operation can take up to 1 sec in some chips, the feature offers convenience to users of flash-based portable computers. Time-critical embedded applications, however, may find it essential.

Every size and shape

Although most flash-storage products are PCMCIA cards, numerous other sizes and shapes are available. PC add-in boards fill a need for high speed and ruggedness when portability isn't a requirement. Embedded applications can use tiny boards for PC/104 and Extremely Small Package systems. For applications requiring ruggedness, package types range from shirt-pocket-sized cartridges to mil-spec modules.

Eurom's DiskOnChip (**Ref 2**) puts a flash disk into a single IC package. Useful for embedded-PC applications, DiskOnChip includes not only flash memory, but also a disk-emulation

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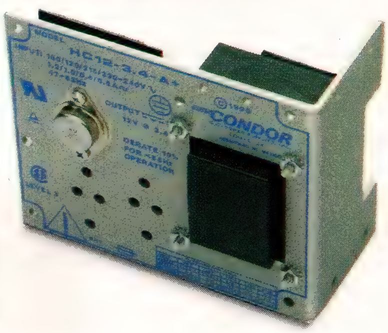

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CIRCLE NO. 72

FLASH DISK

controller (which includes flash-control firmware) and a replacement BIOS. Eurom claims you can add flash disk to a system simply by replacing a BIOS ROM. DiskOnChip comes with storage capacities from 1 to 16 Mbytes.

Whether flash memory can successfully compete against higher capacity, general-purpose disk drives remains to be seen. At high capacities, flash's advantages of ruggedness, compactness, and speed run up against disk drives' one big advantage—much lower cost/megabyte. And, even though flash's cost/megabyte is dropping, disk drives are keeping pace.

Nevertheless, disk makers are planning for a future that includes flash, whether in mainstream storage products or in specialty products only. Alliances between disk manufacturers and flash suppliers include Seagate and SunDisk, Conner Peripherals (San Jose, CA) and Intel, Quantum and SST, and Maxtor and M-Systems.

Most disk manufacturers, in fact, view themselves as storage companies, not just disk companies. And, apparently, they don't view flash storage as just a flash in the pan. EDN

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LOOKING AHEAD

Expect prices for flash-memory ICs to fall, perhaps dramatically, in the next few months. Many flash manufacturers geared up for large sales to manufacturers of personal digital assistants (PDAs), but the PDA market has yet to take off. As a result, a short-term flash surplus is possible.

The trend toward disk-emulation flash storage will continue. More disk-like products will be available, and designing your own will become easier. The DiskOnChip controller, an IC that now controls Eurom's DiskOnChip flash-storage module, will soon be available to OEMs. The chip provides a disk interface and includes flash-file-system firmware that works with any type of flash-memory IC. In large quantities, it will sell for $11 to $16.

In the long term, increasing memory density will make flash chips more cost-competitive for storage applications. Some 16- and 32-Mbit devices are available, and all flash manufacturers have long-term strategies for producing higher-density ICs. SunDisk, which pioneered disk-emulation flash with a disk-like flash architecture, recently signed an agreement with NEC to jointly develop 256-Mbit flash chips by 1997.

New packaging technologies will also boost flash-storage density. Cubic Memory Inc (Scotts Valley, CA, (408) 438-1887) has developed a technology for connecting memory wafers, wafer segments, and dice in stacks. Use of the technology could put 100 Mbytes of flash memory into a PCMCIA card and increase the percentage of usable memory dice, reducing cost/megabyte. The company isn't saying how much the cost/megabyte will fall, however, and a much lower cost will be necessary to sell cards with such high capacity. The company's first flash cards are due in early 1995.

CIRCLE NO. 33

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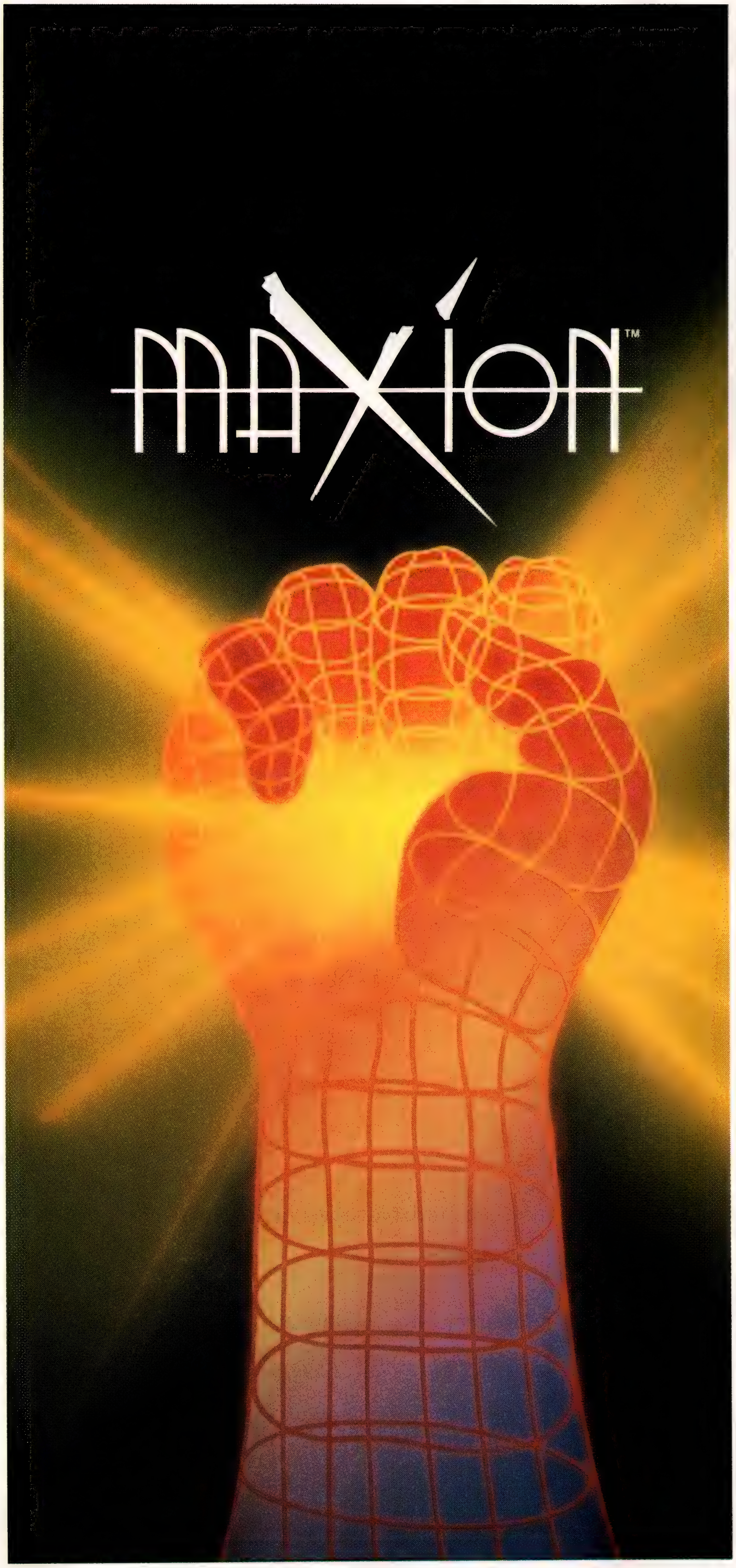

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CIRCLE NO. 73

HIGH-SPEED CONNECTORS' ELECTRICAL PROPERTIES ECLIPSE MECHANICAL TRAITS

CHARLES H SMALL, SENIOR TECHNICAL EDITOR

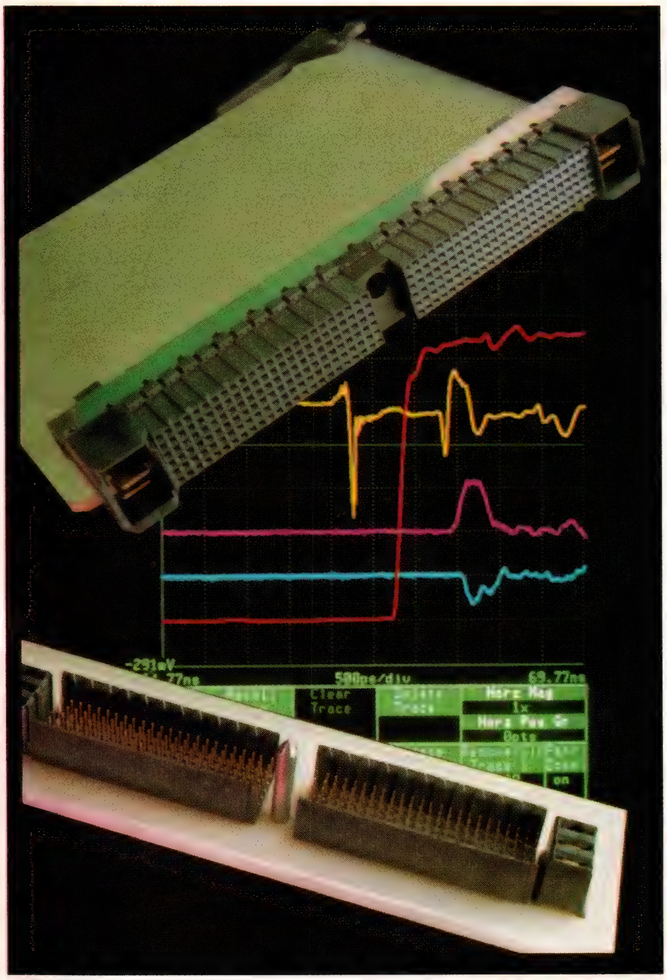
An old mariner's maxim, "Keep an even strain," applies equally well to electronics as it does to handling the lines on a sailboat. Every increase in integration, doubling of bus width, and increase in system-clock speeds throws a terrible strain on interconnections.

Inexorably, increasing bus widths and system-clock speeds pull connectors in two directions at once. On the one hand, connectors must pack more and more signal pins into smaller and smaller spaces. On the other hand, the increasingly short rise times and higher power levels of those signals mandate more shielding to reduce crosstalk. Without proper interconnections, faster devices don't run faster; they just generate more noise.

> Faster rise times and wider buses have changed all the old rules of thumb. Where you could once spec connectors by the seat of your pants, now you must rigorously analyze connectors.

As system clock speeds are passing the magic 50-MHz milestone, signal rise times are doing the limbo underneath 1 nsec. The number of parallel lines that have to be routed have doubled, redoubled, and doubled again. Consequently, the power to drive longer backplanes and cable runs, as well as the number of lines switching at once, have all increased. These trends, taken singly or together, are prescriptions for noise and crosstalk.

Connectors used to be innocuous components, fungible items with simple properties. All connector brands were pretty much the same, and you could solder them on as an afterthought. But now,



Key signal-integrity performance measurements you need to make when evaluating digital board-to-board interconnections include time-domain reflections (yellow), transmitted signal (red), and backward and forward crosstalk (magenta and blue, respectively). (Photo courtesy Teradyne Connector Systems)

the physics of the connector is having a profound effect on signal integrity.

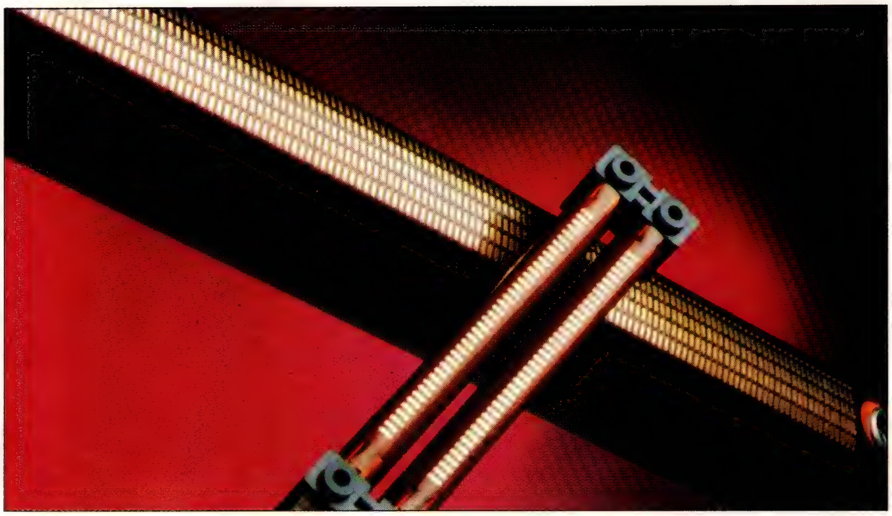
Your best bet is to do extensive and thorough simulations of your interconnections up front to avoid designing yourself into a corner. If you leave connectors to the last, you will likely find yourself using expensive connectors and incurring high assembly costs. After all, the connector industry always has had connectors for high-speed systems: They call such connectors RF and microwave connectors.

Where old-fashioned board-edge connectors cost around $0.005 per signal line, RF and microwave connectors cost several dollars or more per signal line. The more stringent your specifications for signal integrity and crosstalk, the more your connectors will resemble RF and microwave connectors both in performance and price. For example, many high-performance workstation connectors cost $0.10 to $0.25 per signal line.

3M's SCI connectors offer exceptional high-speed performance. Engineers employ the SCI connectors for rise times ranging from 2 nsec down to 100 psec. Although 3M's SCI connectors mate to standard pc-board header pins, the connectors' sockets are fully shielded. Further, the connector's sockets mate to miniature, 50Ω coaxial cable instead of flat cable (75Ω terminations are also possible).

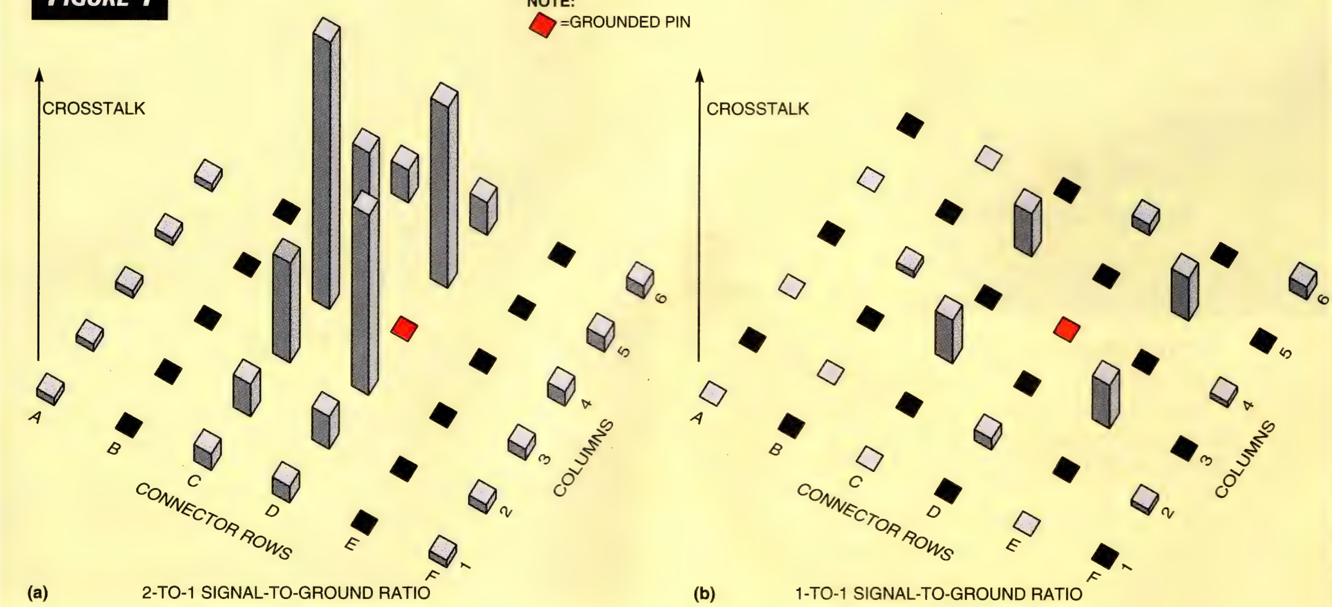
The result is a connection that is quiet enough for analog signals. In fact, 3M also quotes analog specs, such as VSWR and insertion loss, for the connectors. For digital engineers, 0.5-nsec rise-time digital signals experience less than 2% crosstalk. The company has extensive Spice models that it supplies to engineers or uses to perform simulations for customers.

However, stripping and attaching the delicate miniature coaxial cable is a specialized art employing exotic machinery such as laser wire strippers. Consequently, 3M does not sell just the



The AMP-ASC's wraparound flexible circuit can connect as many as five rows of pads on each side of a daughterboard to a corresponding set of pads on the motherboard.

FIGURE 1



These simulations of crosstalk in a six-row, 2-mm-grid backplane connector show a 2-to-1 signal-to-ground pattern (a) and a 1-to-1 checkerboard ground pattern (b) (black squares indicate grounds). A 1-nsec rise-time signal drives pin number D4 in both cases. (Courtesy Teradyne Connector Systems)

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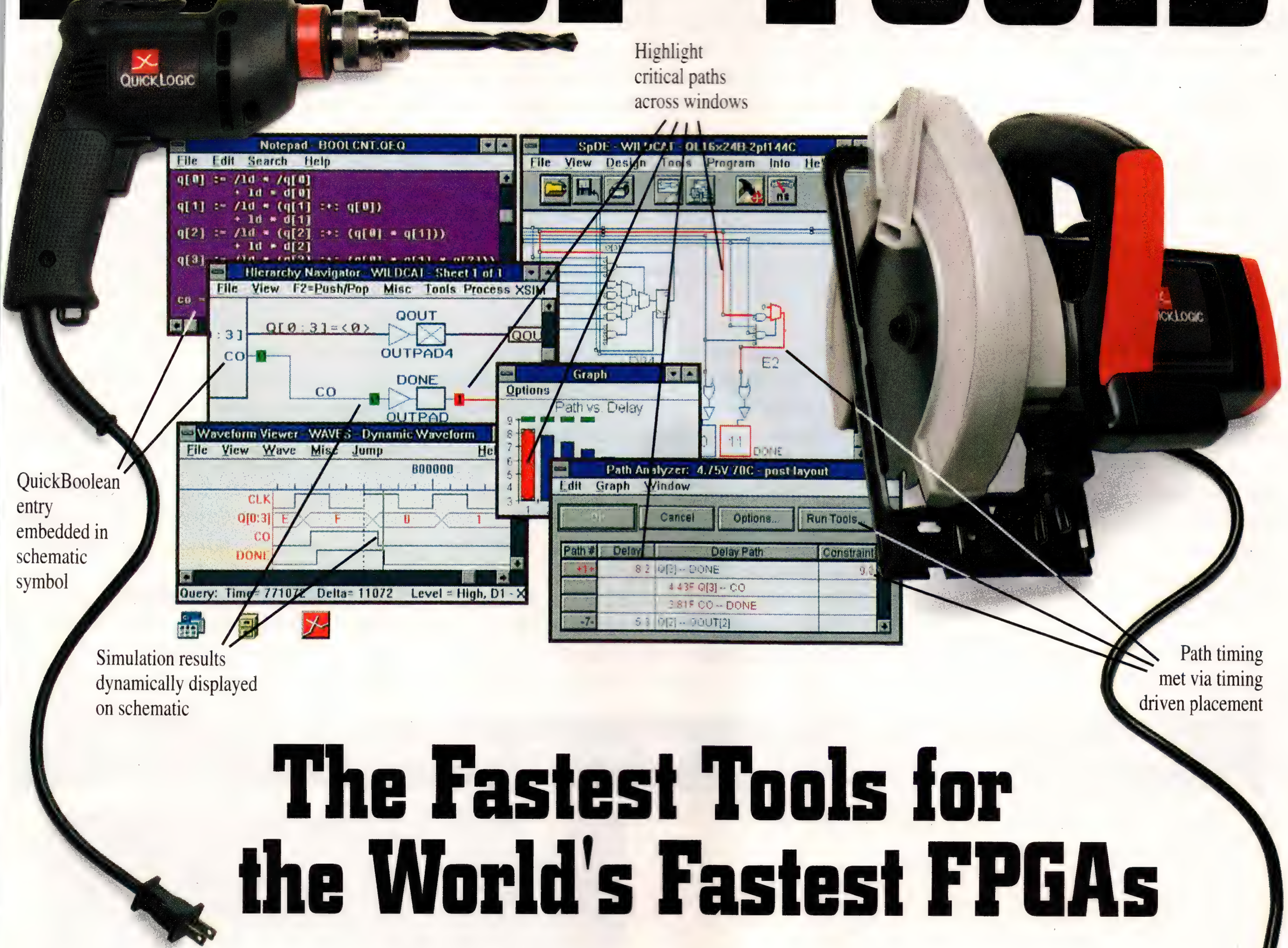

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connectors; it sells only complete custom cable assemblies. A typical 50Ω assembly having five miniature coaxial cables, each a foot long, terminated at one end with a 10-position connector, costs $23.35 each.

Instead of using shielded connector sockets and coaxial cable, grounding signal pins is an alternative for reducing crosstalk. In high-speed applications, engineers commonly sacrifice as much as one-quarter of their signal pins to grounding.

Fig 1 shows simulations of crosstalk in a six-row, 2-mm-grid backplane connector at two signal-to-ground ratios: a 2-to-1 signal-to-ground pattern (**Fig 1a**) and a 1-to-1 checkerboard ground pattern (**Fig 1b**).

A 1-nsec rise-time signal (10 to 90%) drives pin D4 in both cases. Black squares indicate contacts assigned to ground. All other lines terminate in 65Ω. In this example, adding grounds dramatically lowers overall crosstalk by reducing both the number of signal pins that pick up crosstalk and the level of the crosstalk.

The tradeoff obtains lower crosstalk at the expense of interconnection density: 38.1 signals/in. for the 1-to-1 signal-to-ground pattern vs 50.8 signals/in. for the 2-to-1 pattern.

To help engineers optimize portions of a backplane for signal-integrity and interconnect-density requirements, some connector vendors offer both standard-signal-pin and internally shielded versions of their backplane connectors, which mate interchangeably with the same backplane-connector half.

No model? no simulation

The starting point for simulating connectors is a good Spice model. Indeed, the Spice model has become a "checkoff" item for many connector shoppers. But there are Spice models, and then there are *Spice* models. For some applications, you can model a connector as an array of simple capacitors that slightly round off signal edges. But, for accurate models of large, high-speed connectors, you need subtle Spice models whose listings can run for more than 100 pages. Such models must account for nonlinear behavior and crosstalk. Including all possible crosstalk terms for a large connector can alarmingly balloon a Spice listing.

So, you have two possible tacks. You can subcontract a connector company to design your interconnection system. A relative handful of companies, including Amp, Molex, Teradyne, and 3M, has considerable, hard-won, in-house expertise in high-speed connectors. This expertise is available as application assistance or on a fee basis, depending on the company's policy and your needs.

The other tack is to use the connector companies' Spice models as starting points for your own in-house simulations. The decision on which path to take rests more on such imponderables as your company's corporate culture than it does on engineering issues.

Kiss sunk costs goodbye

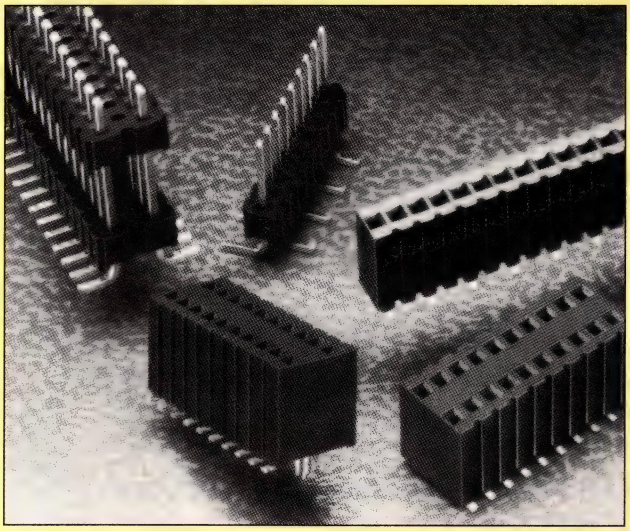
Your company may want to do as much "congruent engineering" as possible to shorten development cycles. Or

MECHANICAL SPECS PROFOUNDLY AFFECT YOUR CONNECTOR CHOICE

Because the connector companies have catered to their largest customers, large companies, such as IBM, have long set the de-facto mechanical standards for everyone's connectors. For example, the current de-facto standard for insertion force is about 1 oz/contact. However, as the number of contacts per connector goes up, the total insertion force cannot go up proportionally because you would not be able to insert the boards.

The easiest way to make a pair of connectors easier to mate is to decrease the contact pressure between their contacts. Not too long ago, the de facto standard for "normal," or perpendicular, forces between the mating surfaces of connectors was 100g. Now that low-insertion-force connectors are necessary, the standard-setting large companies are satisfied with 50g. Connector companies have devoted much effort to this dilemma. Molex, for example, can deliver as high as 75g of normal force/pin in a low-insertion-force connector.

More subtly, mechanical engineers designing connectors speak of hertz forces. At a microscopic level, two mating surfaces, however smoothly polished or coined, actually have tiny peaks and valleys. The physical contact takes place only between the peaks of the two surfaces. Therefore, the surface finish and material of the surfaces have important effects on the quality and endurance of the electrical contact. After performing an abstruse calculation, mechanical engineers quote hertz forces in so many thousands of lbs/sq in. (kpsi). Absent a mechanical-engineering degree, your best bet is to nod wisely and accept the mechanical engineer's opinion on how many thousands of lbs/sq in. are adequate for your application.



Stacking connectors use a lot less metal to get a signal from one board to another compared to a motherboard, yielding good electrical performance at low cost. (Courtesy Samtec)

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			540		
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		P•I-L	9×7×5		
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CIRCLE NO. 109

your company may view software development as a sunk cost that unquestionably deserves to be recovered. (This lack of understanding of basic accounting has put a lot of bad software on the market at high prices.) In these cases, turning the connector development over to a connector company may make the most sense in the short term.

But perhaps your company views Spice simulation as an inexpensive investment in hardware R&D—an investment that pays big returns in the form of a low-cost, reliable, and manufacturable product. In this case, refining your own Spice models so that they accurately predict connector performance in your system could be the way to go in the long term.

Indeed, in the past, connectors were solely the purview of mechanical engineers. Lately, connector companies have had to learn how to talk about electrical properties to electronic engineers. So mechanical engineers now discuss bandwidth and percentage crosstalk. Similarly, electronic engineers have had to learn how to talk about mechanical properties with connector companies.

On your own

However, not all connector companies can provide the same level of application support as, say, μP or analog-IC companies can. The connector industry is cost-competitive. Many companies are doing all they can simply to mold plastic, shape contacts, and assemble connectors as rapidly as possible. The profit margins in the industry simply do not allow connector companies to spend as much on R&D as do semiconductor companies. So, in general, be prepared to do your own signal analyses.

Curiously, connector companies have not spun off commercial versions of their high-speed connectors for military systems. Military designers often need high-density connectors. Such MIL-SPEC connectors require thick gold plating, durable materials, and exotic finishes. Military connectors do not use the pins and sockets of DIN-style connectors. The contacts of military connectors resemble miniature tuning forks and blades, with the tuning forks on the backplane and the blades on the daughterboards. Military connectors have progressed from the early 40-pin SEM A connector to connectors having 200 to nearly 400 contacts within a standard 4.55-in. footprint.

Molex is one connector company that *does* make a commercial fork-and-blade connector. Molex's Low-Force Helix connectors use a split-beam contact that mates with a slightly twisted male blade, minimizing the abrupt ramp angle of pin-and-socket contacts. This connector exhibits insertion force of 1 oz/contact, 75g normal force/contact, and hertz forces of 225,000 lbs/sq in. (225 kpsi).

The twisted male blade provides additional mechanical strength, since it is more substantial than the conventional male pins in most 0.050-in. center connectors. The connectors work at

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frequencies up to 1 GHz. They are available in 0.050- and 0.075-in. center models. Prices range from $0.08 to $0.16 per contact.

Flexible circuits aren't cheap

Flexible-circuit connectors that have been used in military applications haven't found many commercial uses. Flexible circuitry allows improved signal integrity between multilayer boards and the connector and high contact density.

Amp, however, *has* adapted flexible circuit boards to an innovative upgrade of the edge connector. The AMP-ASC can connect as many as five rows of pads on each side of a daughterboard to a corresponding set of pads on the motherboard. The connector starts with a U-shaped plastic channel. Then, a sheet of flexible circuit board wraps around the plastic channel.

The two ends of the flexible circuit board that are inside the channel's slot bear pads that mate with pads on the daughterboard in the slot. Similarly, pads on the portion of the flexible circuit board that passes under the plastic channel mate with pads on the motherboard.

To ensure good electrical contact, the U-shaped channel has long, small-diameter springs set into longitudinal grooves on the inside of both sides of the channel, as well as along the bottom. Under pressure, the springs' coils compress and tilt slightly to the side—a behavior that the company calls "canting." Inserting the daughterboard compresses the springs inside the channel. Bolting the connector to the motherboard (using a reinforcing bar on the underside of the motherboard) compresses the springs on the bottom of the channel.

The connector handles subnanosecond rise times and provides as many as 200 matched-impedance signal lines/in. It costs $0.10 to $0.30 per line.

Swords into plowshares

Despite the proven performance of high-speed military connectors, the central sticking point for their commercial use is the industry's inability to make a military connector at a commercial price. Apparently, beating today's MIL-SPEC swords (or $400 screwdrivers) into commercial plowshares takes something more akin to alchemy than mere blacksmithing.

Instead, many of today's high-speed connectors descend from the DIN connector. The two-piece DIN connector was the first widely used alternative to the ubiquitous one-piece edge connector. The DIN connector provides a maximum of 96 contacts arranged in three rows on a 0.100-in. grid.

Before engineers became concerned with signal integrity, they evaluated connectors and backplanes against mechanical criteria. Density, their only real concern, meant simply adding more rows to two-piece connector designs. Thus, the three-row DIN gave way to four-row, high-density types, and versions having more closely spaced pins are available.

Signals still have to get into tightly spaced connector pins. So staggered pins are common in high-density connectors. Low-current signal pins aside, you can distribute your backplane's power via external top-side busing, internal copper-core busing, or combinations of these techniques.

For example, Teradyne's High Density Metric connectors are Futurebus+ compatible. They contain a six-row array of contacts arranged on a 2-mm grid. You can mix end-stackable signal, power, and polarizing-guidance modules in any configuration. Signal modules contain either 72 or 144 contacts. Daughterboard connectors come in two styles: standard and shielded. The finished product, costing $0.15 per line, comes with a custom multilayer pc backplane, backplane and daughterboard connector assemblies, power busing, and a card cage. EDN

LOOKING AHEAD

One way to reduce connector-induced problems and connector-related costs is to eliminate as many connectors as possible from your design. **Ref 1** details a Motorola VMEbus design that lowered cost by, among several stratagems, eliminating the computer's backplane and using stacking boards instead. The company had to perform extensive Spice simulations of the board-to-board connections to meet VMEbus specs without having a VMEbus backplane in the circuit.

Using board-to-board connectors instead of a motherboard is an idea that comes and goes. But stacking connectors use a lot less metal to get a signal from one board to another compared to a motherboard, giving good electrical performance at low cost. Therefore, stacking connectors may experience yet another resurgence in popularity.

Amp's AMPMODU Metristak surface-mount connectors provide a 50-psec connection between two pc boards. The connectors signal paths are on 1-mm centers, and the board-to-board spacing is 5 mm. A 50-position connector costs $0.10 per signal line (5000).

Samtec's RSM and HTMS series provides surface-mount sockets and headers having pins on a 0.050× 0.100 grid. A mated pair measures 0.465 high. Cost for the sockets is $0.06 per pin, and the headers range from $0.035 to $0.04 per pin.

Reference

1. Small, Charles H, "Shrinking devices put the squeeze on system packaging," *EDN*, February, 17, 1994, pg 41.

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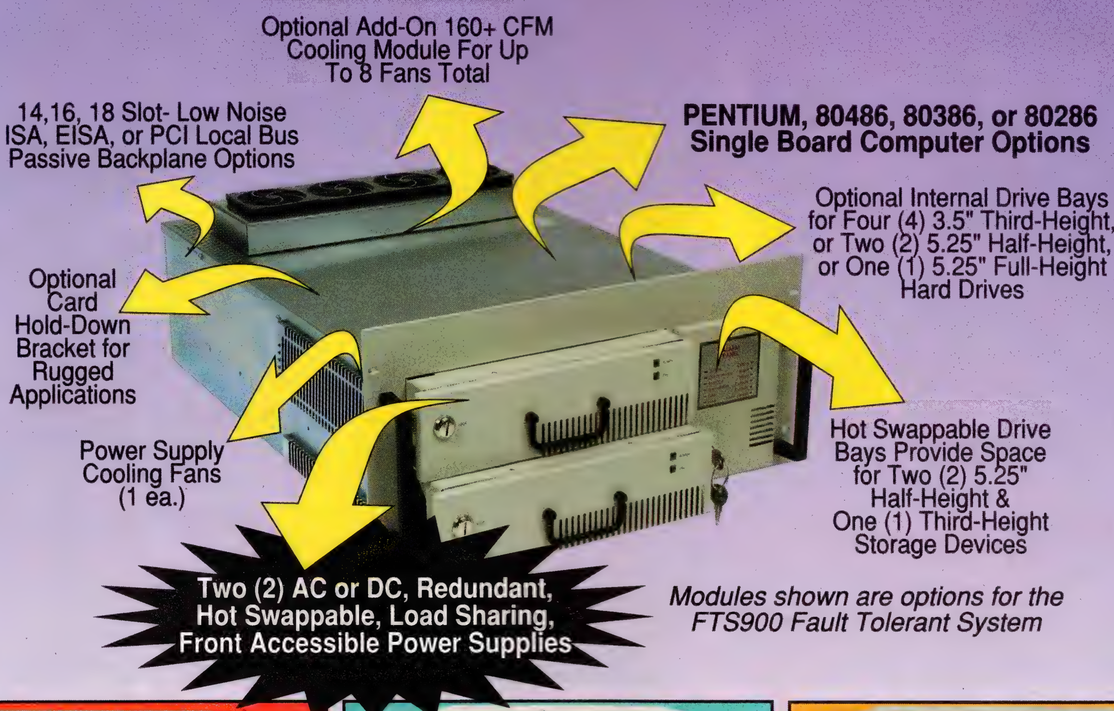

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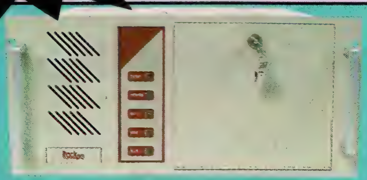

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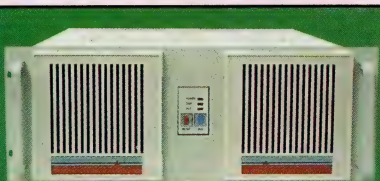

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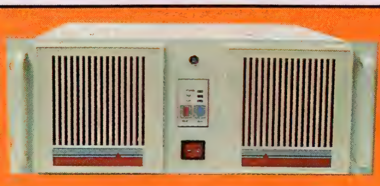

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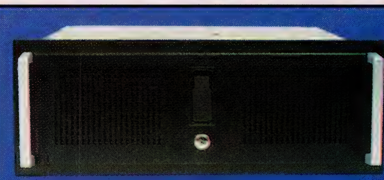

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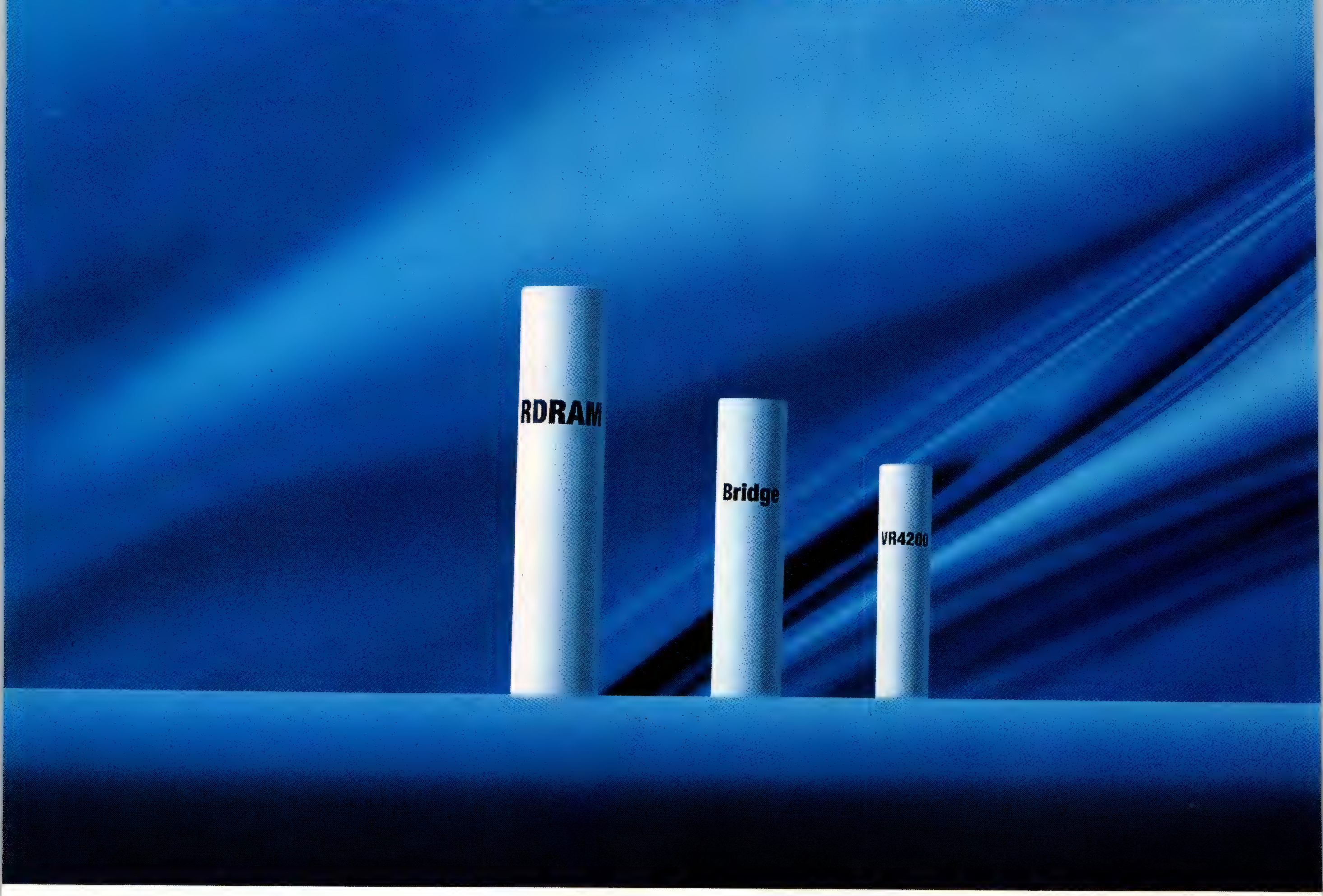

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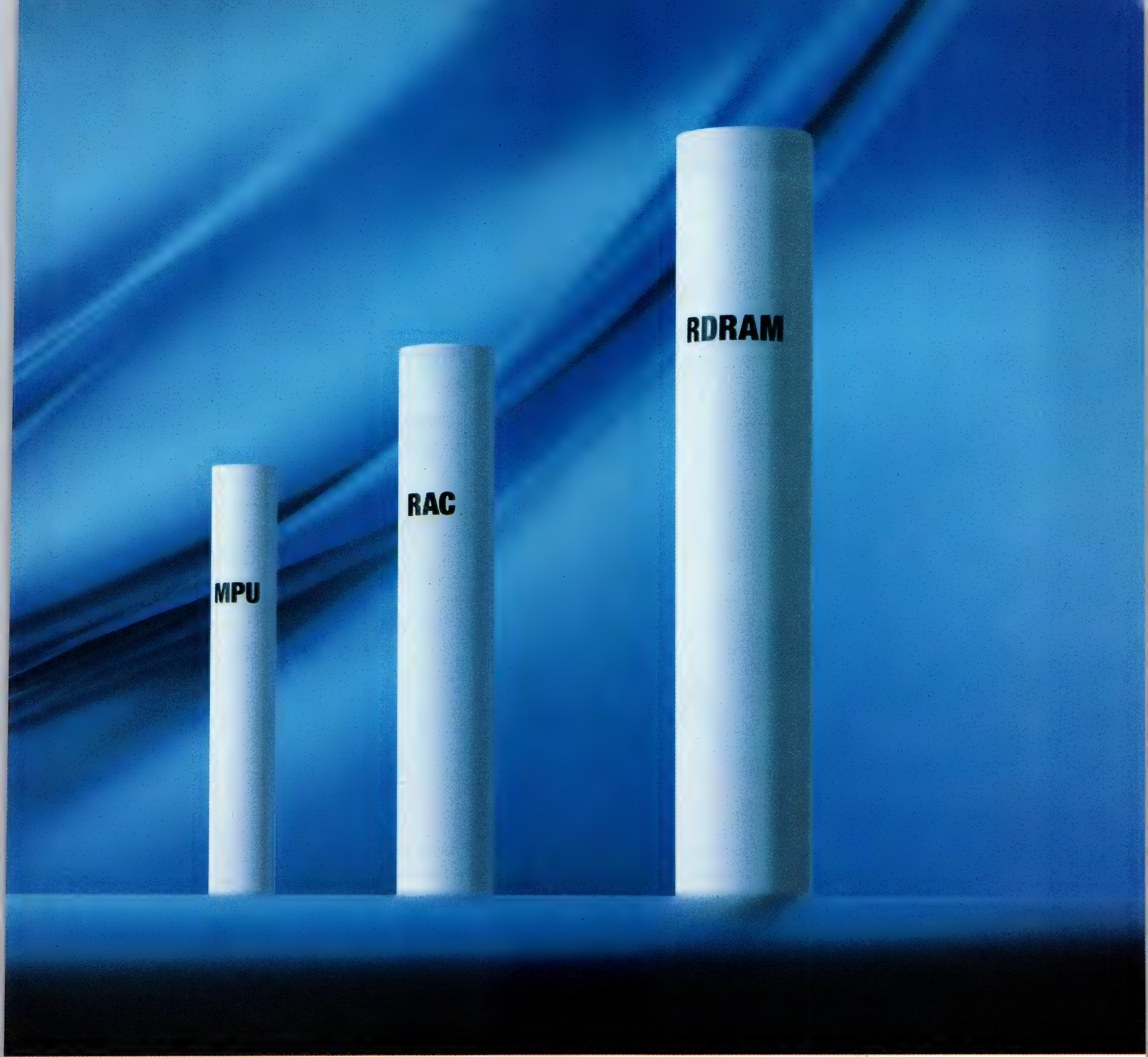

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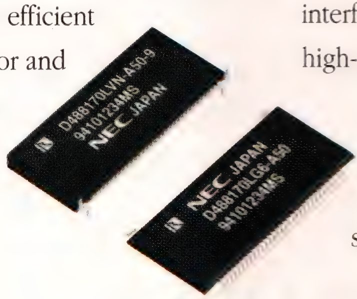

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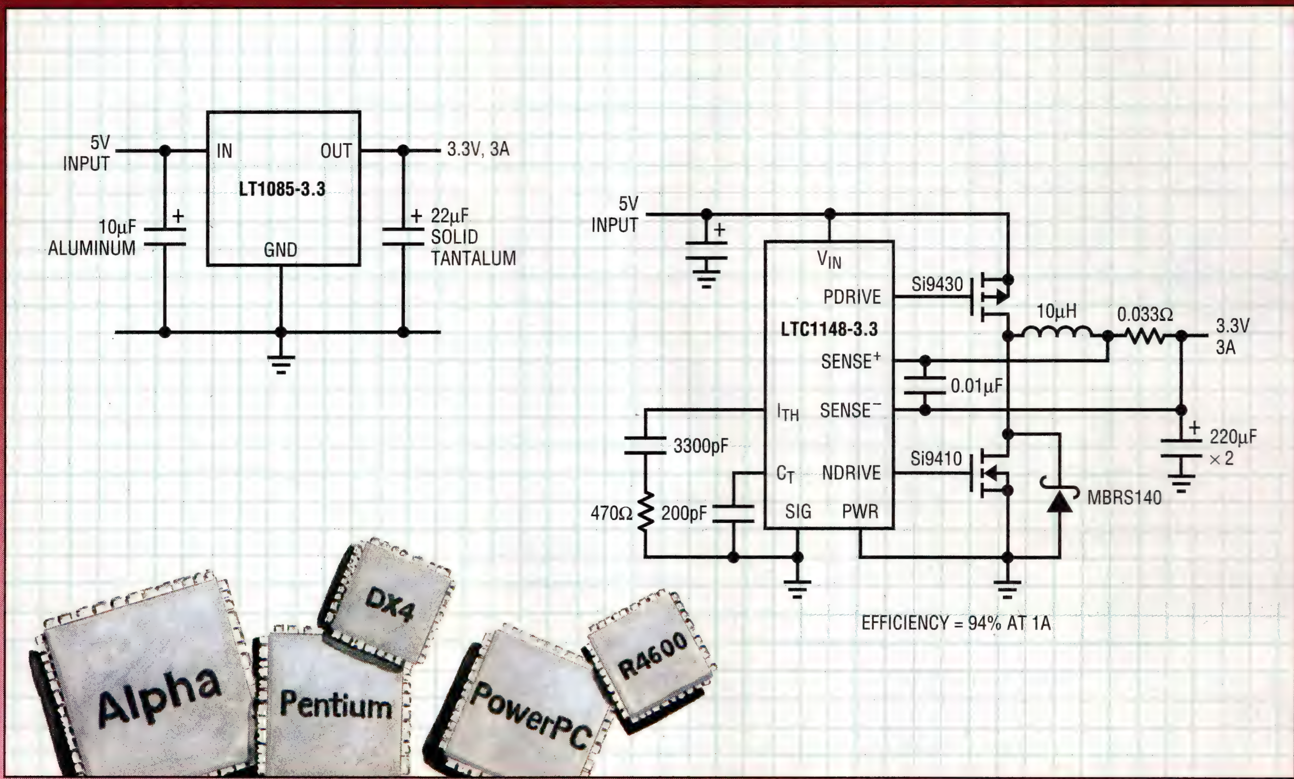
CIRCLE NO. 147

5V→3.3V: Linear or Switcher?



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Output Current	Linear Regulator	Switching Regulator
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3A	LT1085-3.3	LTC1148-3.3
5A	LT1084-3.3	LTC1148-3.3
7.5A	LT1083	LTC1148-3.3
10A	LT1087 (X2)	LT1158
15A (20A Peak)	N/A	LT1158

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LINEAR TECHNOLOGY

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AND EVERYTHING IN BETWEEN.
CIRCLE NO. 146

EDITED BY CHARLES H SMALL & ANNE WATSON SWAGER

Solid-state relay saves battery's life

TOM GAY, SIEMENS, REGENSBURG, GERMANY

The circuit in **Fig 1** uses a low-resistance p-channel FET, Q_4, to disconnect a load from the battery when the battery's voltage drops below a certain value. After you disconnect the circuit, it remains off until you remove and replace the battery.

Q_4's minimum gate-source threshold determines the minimum operating battery voltage of the circuit. For most FETs, this minimum battery voltage is 5V.

The circuit's operating current is low; using the resistor values in **Fig 1**, the circuit consumes less than 6 μA from a 9V battery. The circuit also features a wide input-voltage range, which depends on the maximum collector-emitter voltage rating of the transistors Q_1 through Q_3 and the FET Q_4.

In operation, Q_1 and Q_2 form a Schmitt trigger that senses the circuit's output voltage. In normal operation, Q_1 is on while Q_2 is off. R_5 and R_6 pull the base of Q_3 high, such that Q_4's gate-source voltage across R_8 equals $-V_{BATT}$. For battery voltage higher than 10V, select R_9 according to

$$R_9=R_8(V_{BATT}/V_{GS\ max}-1).$$

However, the circuit does not need R_9 if the battery's voltage is 10V or less. D_1 generates a reference voltage of approximately 1.4V. Because the current through D_1 is low, use the common low-current trick of substituting an LED for a Zener diode. An LED has lower dynamic resistance than a Zener diode does at low currents.

The voltage divider R_1, R_2, and R_3 trim the minimum output voltage at which the Schmitt trigger toggles. When the Schmitt trigger toggles, it turns Q_1 off and Q_2 on. To turn Q_3 on, Q_3's base voltage must decrease to a value below the transistor's $V_{BE\ min}$:

$$V_{BE}(Q_3)=R_7/(R_6+R_7)(V_{LED}+V_{CE\ sat}(Q_2)).$$

Q_3 turns off, and Q_4's gate-source voltage goes to zero. Q_4 disconnects the load. Depleted batteries sometimes recover some of their voltage (but none of their capacity) after disconnection. To avoid reconnection of a depleted battery, the load remains disconnected, even if the input voltage slowly rises again.

Only inserting a new battery resets the circuit. After you remove the old battery from the circuit, leakage currents discharge capacitors C_1 and C_2 in a couple of seconds. When you insert a new battery, the gate-source capacitance of Q_4 charges with the current flowing into C_1, connecting the load. For safe turn-on, C_1 must now be less than the gate-source capacitance of Q_4. Keeping C_1 below three times Q_4's gate-source capacitance ensures a reasonable reset time for the circuit.

Replacing potentiometer R_2 with an NTC resistor protects the battery from excessive temperatures. Diode D_2 should be in good thermal contact with transistors Q_1 and Q_2 to reduce the influence of junction temperatures on the turn-off voltage. You could also consider paralleling FETs to increase output-current capability and decrease resistance. The optional switch S_1 resets the circuit to an on state and proves useful if the load experiences a temporary short circuit. (DI #1584)

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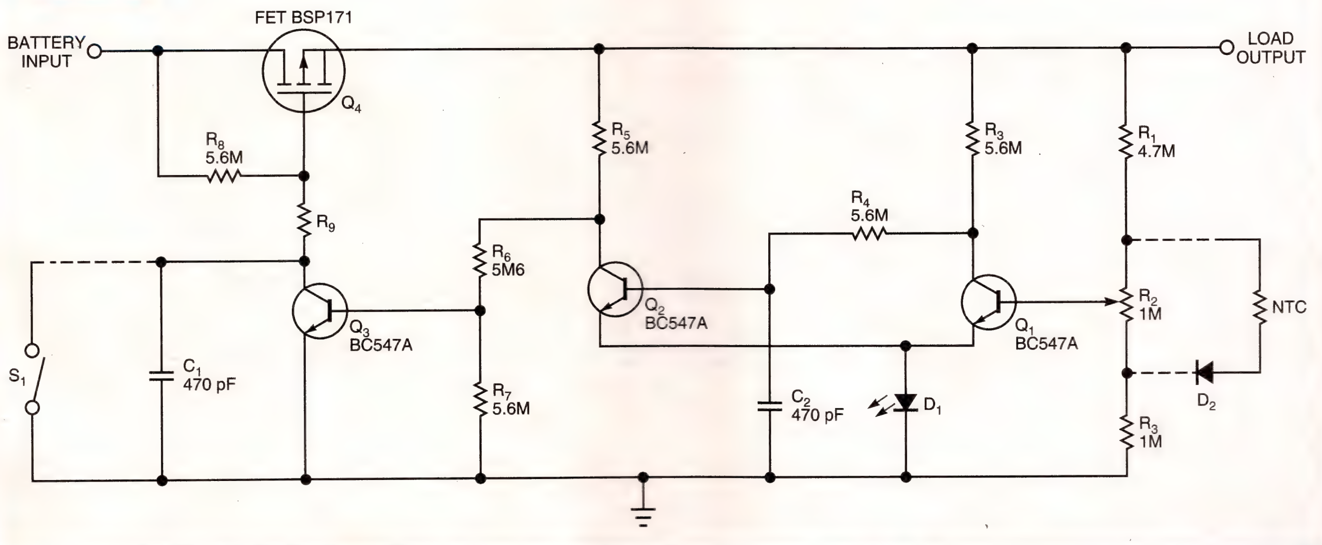
FIGURE 1



This solid-state relay disconnects a depleted battery and does not reconnect the load until you insert a fresh battery.

Off-hook phone line supplies 150 mW

RON CLARK AND BOB UNDERWOOD, MAXIM INTEGRATED PRODUCTS, SUNNYVALE, CA

For systems that require 150 mW or less, the power supply in **Fig 1** draws power from ordinary phone jacks without interrupting the voice signal, thereby eliminating the need for batteries and ac adapters. Built into peripheral equipment such as PCMCIA modem cards, this circuit can spare the battery in a host computer. The circuit is useful in portable systems that connect to subscriber (household) telephone lines, such as modems and telephone test sets.

The line current available to a telephone in the off-hook state is limited not by regulations or code, but by only the sum of impedances in the central-office battery and intervening phone lines. These line impedances vary greatly in proportion to distance from the central office, so the customary practice of matching impedances for maximum power transfer is impractical.

However, D_1's zener-clamp termination works well for line impedances to 1 kΩ and for worst-case conditions. This termination also meets the one condition imposed on line current by the phone system: Off-hook current must exceed 20 mA to ensure activation of a network-access relay in the central office.

D_1 provides approximately 6.8V to the center tap of T_1 and 5V to the V_{CC} terminal of IC_1, a 400-kHz oscillator driving an internal flip-flop. IC_1 generates two push-pull, 50%-duty-cycle, 200-kHz square waves that drive internal, ground-referenced switches connected to the primary of T_1. On the secondary side, Schottky diodes D_2 and D_3 rectify the isolated power, which IC_2's low-dropout regulator then regulates to 5V.

T_1's primary is a center-tapped winding whose ET product (a voltage-time product of 25V μsec) is sufficient to prevent saturation under worst-case conditions. Similarly, T_1's turns ratio should provide the minimum required output voltage for maximum load and minimum input voltage. The calculation for the turns ratio should also assume worst-case losses in D_2 and D_3.

The resultant turns ratio produces a much higher secondary voltage for best-case conditions, which is acceptable for some applications. If not, you can add a linear regulator (IC_2). For isolated 5V outputs, the ideal turns ratio is 1.2CT:1.0CT (CT=Center Tapped). Wind the transformer on Magnetics Inc (Butler, PA, (412) 282-8282) "W," Fair-Rite "76," or other high-permeability magnetic material. To minimize radiated noise, choose a pot core, E/I/U core, toroid, or other geometry with closed magnetic paths.

Consider a typical toroid, such as the 40603-TC, which is 0.125 in. thick with a 0.230-in. outside diameter. For 6.8V inputs, this core should have a 48-turn primary (24 turns on either side of the CT), which yields a nominal end-to-end primary inductance of 8 mH. You can scale the secondary for any reasonable output voltage. For example, 40 turns (20 turns on either side of the CT) delivers 5.2V min, as required by the linear regulator for maintaining a regulated 5V output.

For isolated 3.3V applications, the minimum voltage to IC_2 is 3.5V. T_1's turns ratio should be 2.0CT:1.0CT, with a primary ET product of at least 25V μsec. If you use the same 48-turn primary as for 5V applications, the required number of secondary turns is 24 (12 on either side of the CT). In addition, you must add a resistive divider for setting IC_2's regulated output to 3.3V.

Q_1, Q_2, and the associated resistors ensure a low-power shutdown mode for IC_1 until its supply voltage can sustain a full power-up. IC_1's supply current is fairly constant, so light filtering (by L_1 and C_3) is sufficient to prevent noise from entering the hybrid transformer (not shown). (DI #1573) EDN

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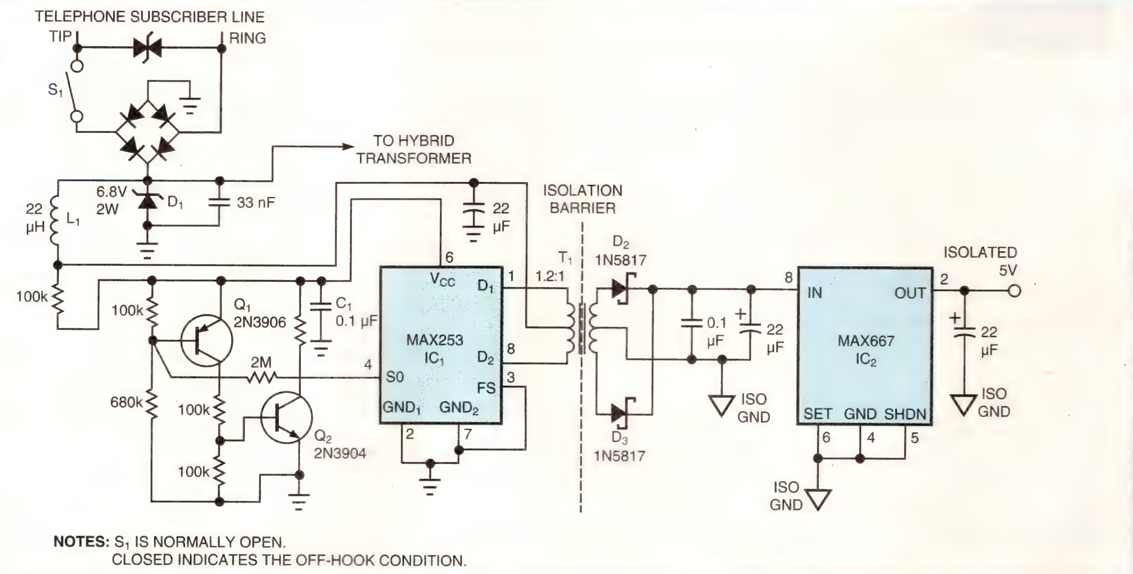
FIGURE 1



This circuit draws current in the off-hook condition, delivering as much as 150 mW of isolated power while allowing normal voice or data communications over the phone line.

Cúk converter yields 90% efficiency

PETER DEMCHENKO, VN, VILNIUS, LITHUANIA

The simple dc/dc converter in **Fig 1** has an efficiency of 90% min and output ripple measured at 10 mV p-p.

This circuit employs an inexpensive 78L15 regulator in an unusual manner. The regulator, IC_2, operates as a voltage-level shifter. Because the regulator's normal output is tied to ground, the regulator tries to maintain its input at its characteristic 15V above its voltage-reference (V_R) pin's level by drawing the appropriate current through biasing resistor R_1. You can use this trick with any member of the 78LXX family.

The regulator is part of a feedback loop that controls the circuit's pulse-width modulator. The pulse-width modulator comprises Q_1, gate IC_{1B}, and associated components. The Cúk configuration of the output stage, comprising Q_2, Q_3, and the transformer, has inherently low input and output ripple.

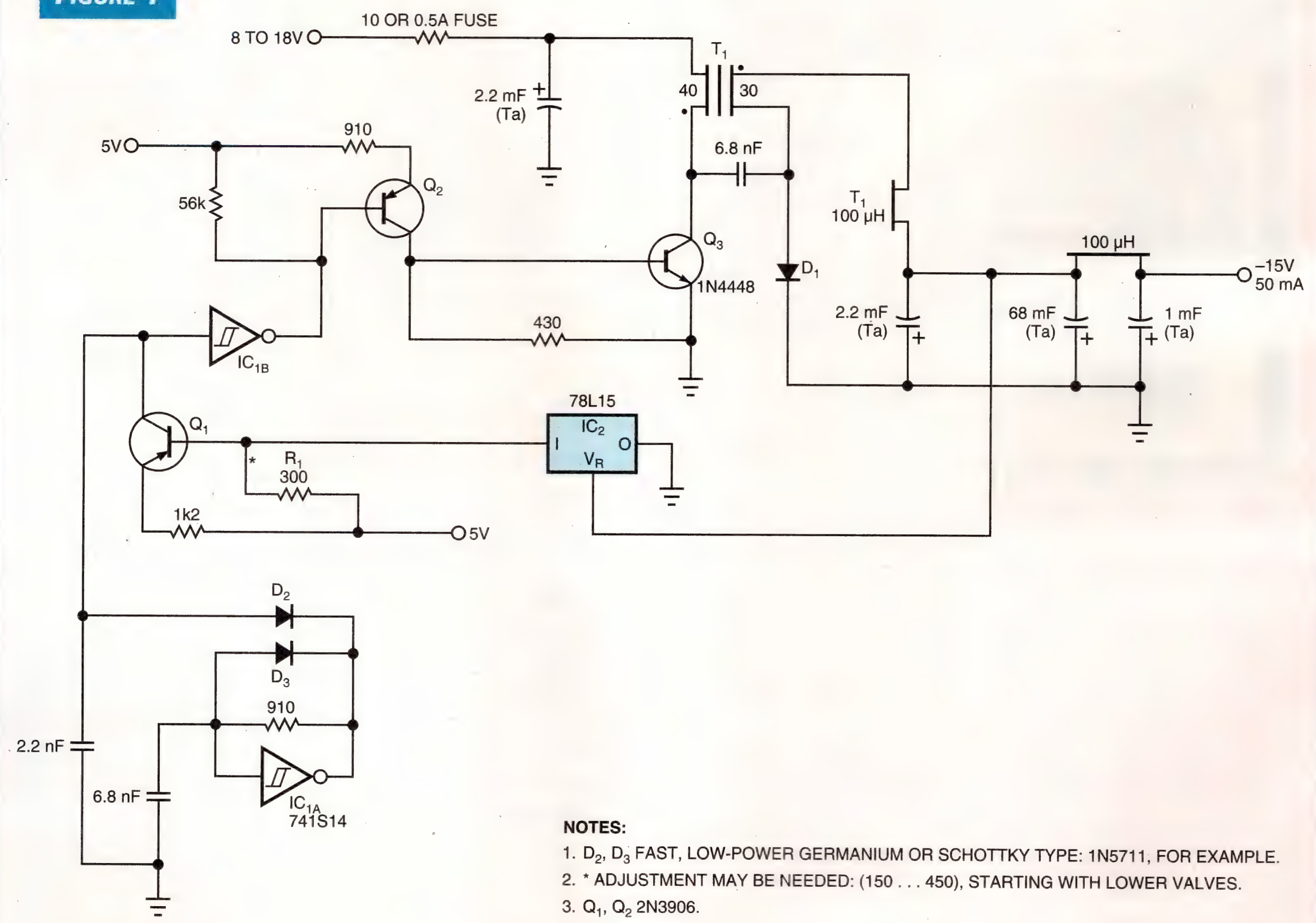
Oscillator IC_{1A} and associated components, which feed the pulse-width modulator, operate at a fixed frequency of 350 kHz, simplifying output-noise filtering. Because of this relatively high frequency, use low-ESR, tantalum-chip capacitors instead of electrolytic capacitors. Similarly, use a fast epitaxial diode for D_1.

A 74HC14 is preferable for IC_1, but the brave old 74LS14 works (component values shown are for the LS version). Select a fast switching transistor for Q_3, which can sustain I_C>1A, V_{CE}>60V.

Transformer T1 is a toroid, 11 mm in diameter having 0.3-mm enameled wire for the primary and secondary windings. Your circuit's layout must be as compact as possible, having no long runs. (DI #1579)

To Vote For This Design, Circle No. 392

FIGURE 1



NOTES:
1. D_2, D_3 FAST, LOW-POWER GERMANIUM OR SCHOTTKY TYPE: 1N5711, FOR EXAMPLE.
2. * ADJUSTMENT MAY BE NEEDED: (150 . . . 450), STARTING WITH LOWER VALVES.
3. Q_1, Q_2 2N3906.

This switching dc/dc converter presses an inexpensive linear voltage regulator into service as a voltage-level shifter.

Two LEDs perform rudimentary spectral analysis

PETER BOJILOV, ISOMATIK SORTEX LTD, PAZARDJIK, BULGARIA

A pair of LEDs having different wavelengths can supply the stimulus for a rudimentary spectral analysis during quality-control sorting operations. By measuring the reflectance of each LED, the circuit in **Fig 1** can provide information about the spectral response of the object under test. The circuit's operation is akin to the human eye's using three receptors to deduce information about the entire visible spectrum.

The circuit in **Fig 1** has two emitters, D_1 and D_2, but only one sensor, a TI TSL250 integrated photo receiver, IC_1. The clock circuit, IC_2, IC_3, and associated components multiplex the single sensor between the two LEDs' outputs, as well as sampling the ambient light.

IC_3's Q_1 and Q_6 outputs turn on an LED and its corresponding S/H amplifier via the NAND-gate chains. The delay networks at the inputs of the NAND-gate chains going to the sensor's S/H ICs compensate for the sensor's output-response delay.

IC_3's Q_4 and Q_0 outputs, diode-ORed together, take a sample of the ambient light when the LEDs are off. The circuit subtracts this reading from the LEDs' readings. The MAX 720 programmable filter, IC_4, cleans up the outputs of two LEDs' reading.

Potentiometers R_1 and R_2 allow you to adjust the LEDs' current between 25 and 400 mA. (DI #1580) EDN

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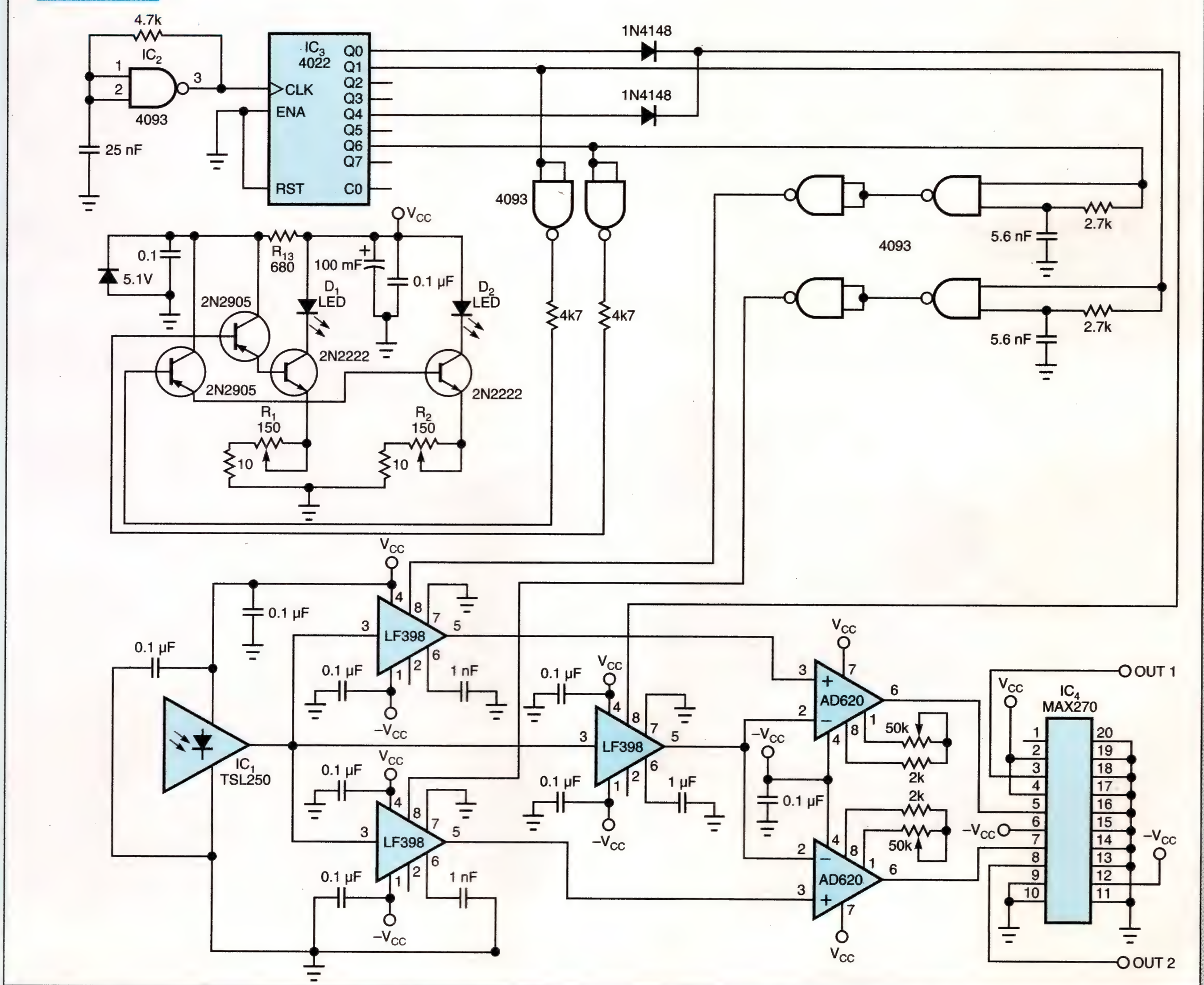
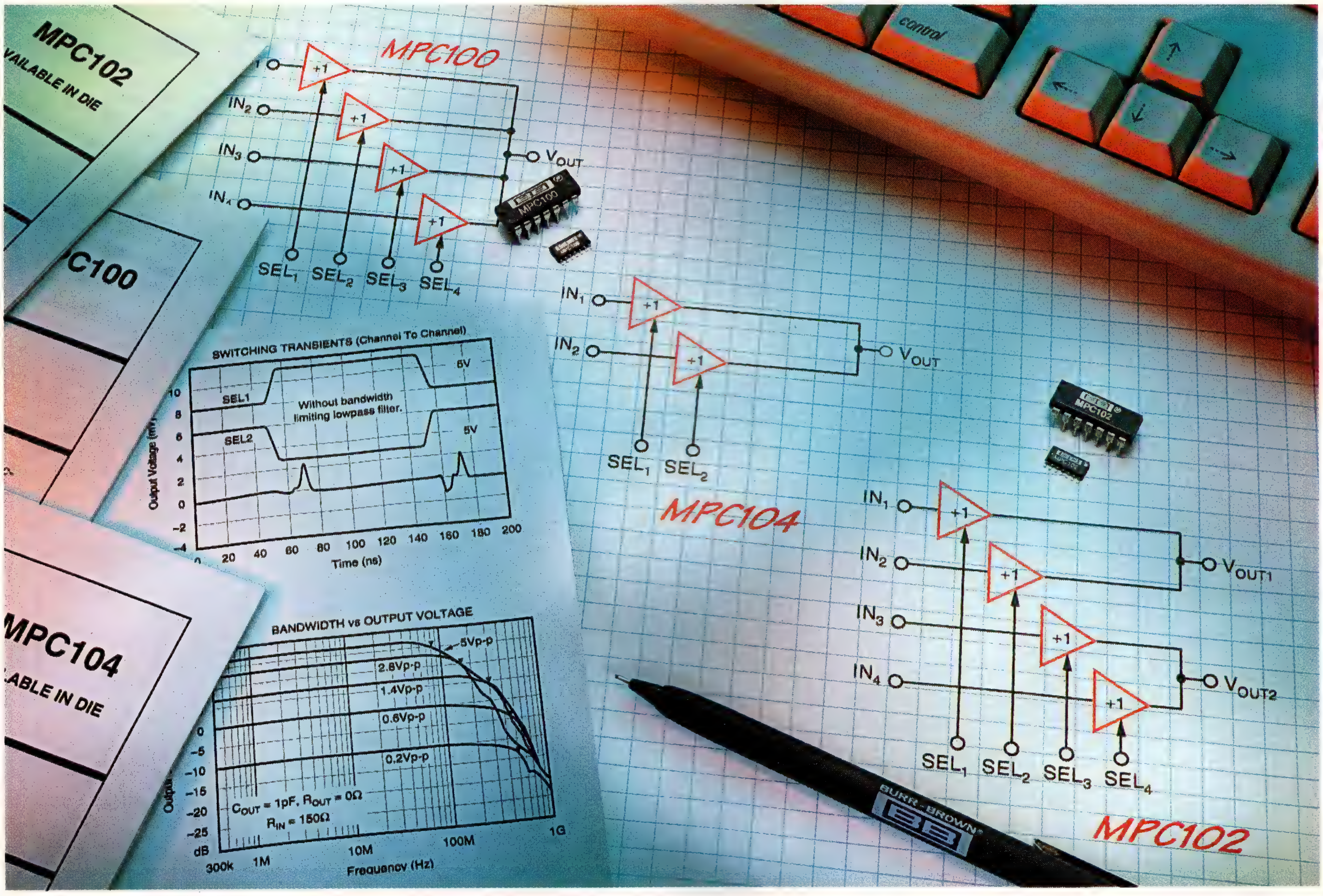
FIGURE 1



Illuminating an object under test by two LEDs having different wavelengths allows you to perform a rudimentary spectral analysis of the object. You can use this simple scheme to sort fruits and vegetables automatically, for example.

Simple Signal Switching Solutions



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- Low distortion .... –64dBc
- Low switching transients .... +6/–8mV
- Low quiescent current .... 4.6mA (one channel selected)
- Low differential gain/phase errors .... 0.02%, 0.02°
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LINEAR TECHNOLOGY

DESIGN NOTES

Ultra-Low Power, High Efficiency DC/DC Converter Operates Outside the Audio Band – Design Note 86

Mitchell Lee

Portable communications products are densely packed with signal processing, microprocessor, radio frequency, and audio circuits. Digital clock noise must be eliminated not only from the audio sections, but also from the antenna which, by the very nature of the product, is located only inches from active circuitry. If a switching regulator is used in the power supply, it becomes another source of noise. The LTC1174 step-down converter is designed specifically to eliminate noise at audio frequencies while maintaining high efficiency at low output currents.

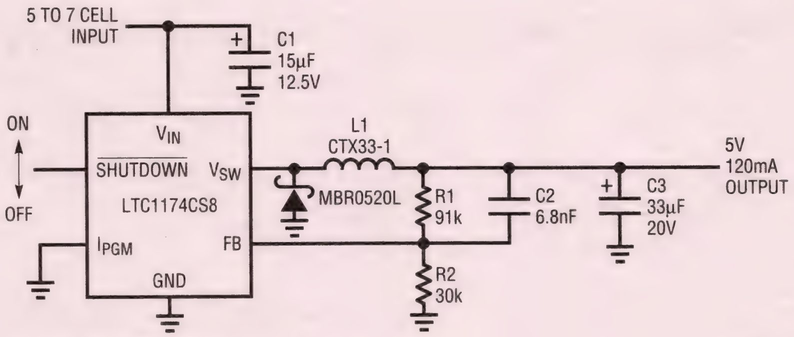
Figure 1 shows an all surface mount solution for a 5V, 120mA output derived from 5 to 7 NiCd or NiMH cells. Small input and output capacitors that are capable of handling the necessary ripple currents help conserve space. In applications where shutdown is desired this feature is available (otherwise short this pin to V_{IN}).

The LTC1174's internal switch, connected between V_{IN} and V_{SW}, is current controlled at a peak of approximately 340mA. Low peak switch current is one of the key features that allows the LTC1174 to minimize system noise compared to other chips which carry significantly higher peak currents, easing shielding and filtering requirements and decreasing component stresses. Output currents of up to 450mA are possible with this device by connecting the I_{PGM} pin to V_{IN}. This increases the peak current to 600mA, allowing for a high average output current.

To conserve power and maintain high efficiency at light loads, the LTC1174 uses Burst Mode™ operation. Unfortunately, this control scheme can also generate audio frequency noise at both light and heavy loads. In addition to electrical noise, acoustical noise can emanate from capacitors and coils under these conditions. A feed-forward capacitor (C3) shifts the noise spectrum up and out of the audio band, eliminating these problems. C3 also reduces peak-to-peak output ripple to approximately 30mV over the entire load range.

A toroidal surface mount inductor (L1) is chosen for its excellent self-shielding properties. Open magnetic structures such as drum and rod cores are to be avoided since they inject high flux levels into their surroundings. This can become a major source of noise in any converter circuit.

Burst Mode is a trademark of Linear Technology Corporation



C1: PANASONIC SP SERIES (201) 348-4630
C3: AVX TAJ SERIES (803) 956-0690
L1: COILTRONICS OCTAPAK (407) 241-7876

Figure 1. Low Noise, High Efficiency Step-Down Regulator for Personal Communications Devices

The interactions of load current, efficiency, and operating frequency are shown in Figure 2. High efficiency is maintained at even low current levels, dropping below 70% at around 800μA. No load supply current is less than 200μA, dropping to approximately 1μA in shutdown. The operating frequency rises above the telephony bandwidth of 3kHz at a load of 1.2mA. Most products draw milliampere range load currents only in standby with the audio circuits squelched, when low frequency noise is not an issue.

The frequency curve depicted in Figure 2 was measured with a spectrum analyzer, not a counter. This ensures that the lowest frequency noise peak is observed rather than a faster switching frequency component. Any tendency to generate subharmonic noise is quickly exposed using this measurement method.

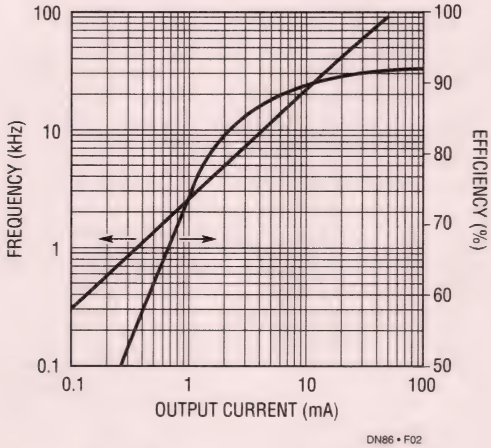


Figure 2. Parameter Interaction

A spectrum analysis of noise from 100kHz to 10MHz is shown in Figure 3. The fundamental switching component in this test was approximately 85kHz, and the second harmonic shows up at twice that frequency. It measures approximately $3mV_{RMS}$. Harmonics of the 85kHz fundamental disappear into a 10μV "mud" between 1MHz and 2MHz. Noise in the critical 455kHz region ranges from 10μV to 300μV, depending on operating frequency. At 10.7MHz, an important and sensitive intermediate frequency, the noise is broadband and well below $10\mu V_{RMS}$.

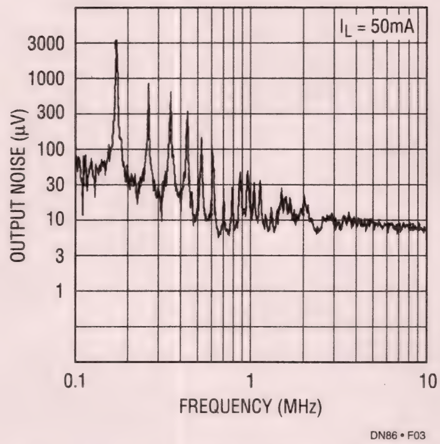
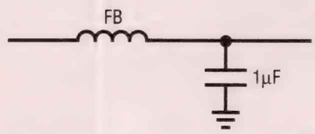


Figure 3. Noise in the 100kHz to 10MHz Band

Further noise reduction is possible by adding an output filter (see Figure 4). A small surface mount ferrite bead is placed in series with the 5V output, close to the LTC1174 and bypassed by a 1μF surface mount ceramic capacitor. Noise attenuation at 10MHz exceeds 20dB.



FB: DALE ILB-1206 31 25% (605) 665-9301
1μF: AVX 12063G105ZAT (803) 448-9411 DN86 • F04

Figure 4. An Effective Filter for Attenuating Noise Components Above 1MHz

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Charge batteries safely in 15 minutes by detecting voltage inflection points

GARY CUMMINGS, SPECTRA RESEARCH, DANIEL BROTTO, BLACK AND DECKER CORP, AND JAMES GOODHART, ZILOG INC

Modern, battery-powered electronic products require rapid charging of NiCd, NiMH, and other types of batteries. But if a fast charger doesn't know when to stop, it can easily cause damage. Conventional means of sensing full charge terminate charging too late. Here's a technique that stops the charging in time.

Consumer demands for portability and convenience create new opportunities for manufacturers of electrical and electronic equipment. As NiCd (nickel-cadmium) and NiMH (nickel-metal-hydride) batteries offer increased capacity and improved durability, rechargeable-battery operation becomes increasingly common. But greater use of battery power challenges product-design engineers: Prolonged recharging times and the need to replace worn-out batteries annoy and inconvenience users. For fast, high-current chargers, conventional control methods often are ineffective, causing gradual battery deterioration—or worse. Furthermore, recent innovations that extend battery life while permitting recharging in 15 minutes or less complicate charger design.

New battery types, including NiMH, lithium-ion, and others, offer better performance than NiCd but at a higher cost. Many conventional intelligent battery chargers utilize dV/dt (slope) detection, which senses changes in voltage exhibited by most batteries in the early stages of overcharge (**Fig 1**). NiCd battery voltage exhibits a characteristic 30- to 50-mV decline after full charge. "Minus-delta-voltage" sensing detects this change, but only after some degree of overcharging. NiCd batteries tolerate some amount of overcharging, especially at low charge currents, but overcharging causes the batteries to deteriorate and gradually lose storage capacity.

When overcharged, NiMH batteries show a decline of just 3 to 5 mV, which is difficult to detect using minus-delta-voltage methods. Recently offered charging controllers for NiMH batteries generally abandon the minus-delta-voltage charging-termination technique in favor of zero-slope detection, which senses a characteristic leveling off of NiMH battery voltage after full charge (**Fig 2**). Because of the subtle nature of the NiMH dV/dt characteristic, this method compromises the accuracy of full-charge detection to achieve noise immunity. Unfortunately, NiMH batteries are intolerant of overcharging, which can be especially troublesome at charge rates of 1C or greater. (C refers to a current numerically equal to a battery's ampere-hour (Ahr) capacity.) High charge currents demand accurate full-charge detection. This article describes and details the cost and performance advantages of an accurate, low-cost, fast-charging control method based on detecting battery-voltage inflection points. The technique works with NiCd, NiMH, and other battery types.

The design task

Fast battery chargers consist of two sections: a power converter, generally configured as a constant-current source, and a charging controller, which enables and disables the power supply in response to selected battery state-of-charge indicators. These indicators are time-variant physical parameters that change predictably through the battery-charging process. Several indicators are possible, including battery voltage, temperature, pressure, and, in the unusual case of constant-voltage charging, battery current. Most conventional chargers monitor battery voltage and/or temperature and analyze them either individually or in combination. The controller generally considers both absolute thresholds and the monitored quantities' rate of change with time. The suitability of a given control method depends on the type of battery and the accuracy needed for full-charge detection. The required accuracy of full-charge detection is a function of the charging-current magnitude.

In a trickle charger, full-charge detection can be approximate. In fact, a low-current charger can charge batteries con-

tinuously until you remove them (**Fig 3**). In this case, the battery's temperature and pressure are elevated above normal but will stabilize within the battery's design limits, causing little or no damage. High charging currents, on the other hand, require accurate full-charge detection. Fast chargers can quickly cause battery damage if they continue to apply high current after full charge.

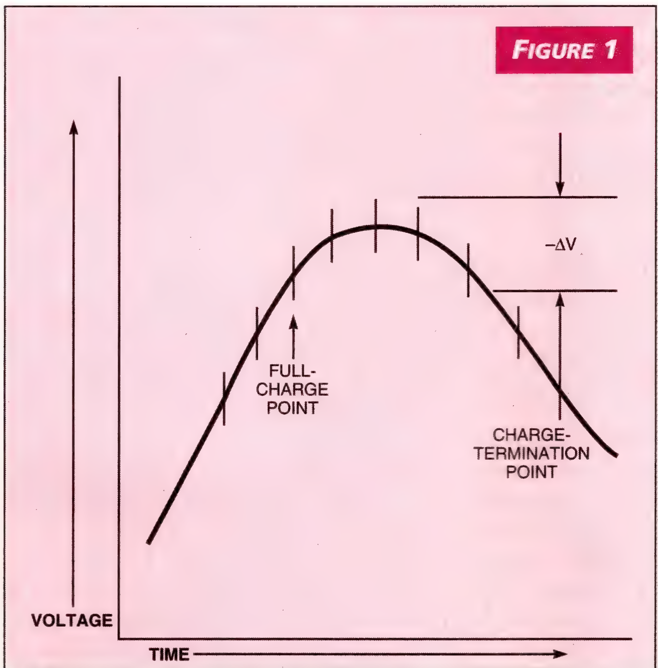
Fast battery charging requires high charging currents. To achieve full charge in 20 minutes, a fully discharged notebook-computer battery pack with 2.2 Ahr capacity requires a 3C charging rate (or 6.6A average). At this charging current, accurate sensing of a full-charge condition is essential to prevent overcharging from causing battery damage. In **Fig 4**, notice that the battery's internal temperature and pressure increase dramatically if high current continues after the battery reaches full charge. For NiCd batteries, repeated or prolonged temperature excursions over 40°C cause gradual loss of the battery's storage capacity. The product's user bears the hidden cost of premature battery replacement. The rate of deterioration depends on the degree of overcharge and the resultant heating. NiMH batteries are more sensitive than NiCd in this respect; a single overcharging event can cause serious battery damage.

Conventional methods of terminating fast charge, which include detection of zero or minus-dV/dt battery-voltage slope and the rate of battery-temperature change, dT/dt, rely on indicators that become evident only after the battery is fully charged. These schemes cause repeated overcharging because the battery is already past full charge when typical charge-termination points are reached.

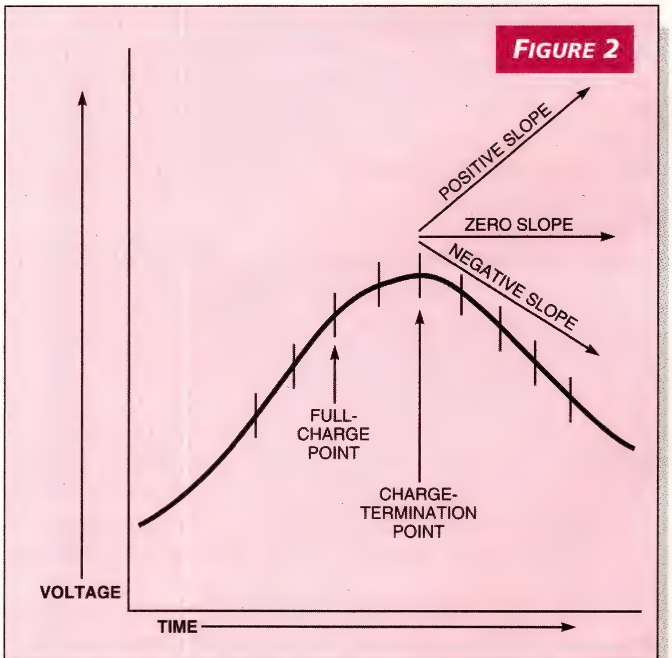
Responding to the need to terminate charging before battery damage occurs, the engineers at Black and Decker developed a combination of proprietary techniques. Using microcontrollers, the Black and Decker engineers designed a series of cost-effective, "smart" battery chargers that enable power-tool users to charge NiCd battery packs in as little as 15 minutes. Years of development and production have refined the production methods. Zilog has licensed these patented techniques for use by purchasers of its microcontrollers. Particular features of Zilog's Z8 architecture, such as the onboard analog comparators, make Z8-based smart-charger designs especially cost-effective.

The primary innovation of the Z8-based smart charger relies on analysis of the battery's voltage characteristic with respect to time. The Black and Decker engineers noted that the battery's dV/dt exhibited predictable, characteristic changes during charging (**Fig 5**). When a fully discharged battery recharges rapidly, there is a brief, sharp battery-voltage increase followed by an extended time interval during which dV/dt is very low. For NiCd batteries, terminating charging during this interval replenishes 70 to 80% of the stored energy. Continued charging causes a distinctly noticeable increase in dV/dt. As battery charge approaches capacity, dV/dt begins to decrease; beyond full charge, the dV/dt goes negative. By the time this occurs, the battery temperature and pressure have begun to increase rapidly because additional energy supplied to the battery cannot be converted to electrochemical potential.

Black and Decker calls the improved technique inflection analysis. An inflection is any point in the battery's charging cycle at which the second derivative of battery voltage with respect to time (d^2V/dt^2) changes polarity (**Fig 5**, points A and B). The Black and Decker technique accurately detects inflec-



If you continue to charge a NiCd battery after it reaches full charge, its terminal voltage actually declines. Some chargers detect this negative voltage change and use it to terminate charging. Chargers based on this phenomenon can't stop the charging until after the battery reaches full charge.



A better charge-termination scheme senses the rate of change (slope) of the battery's terminal voltage vs time. When the slope changes from positive to negative or zero, charging stops. But charging still continues past full charge.

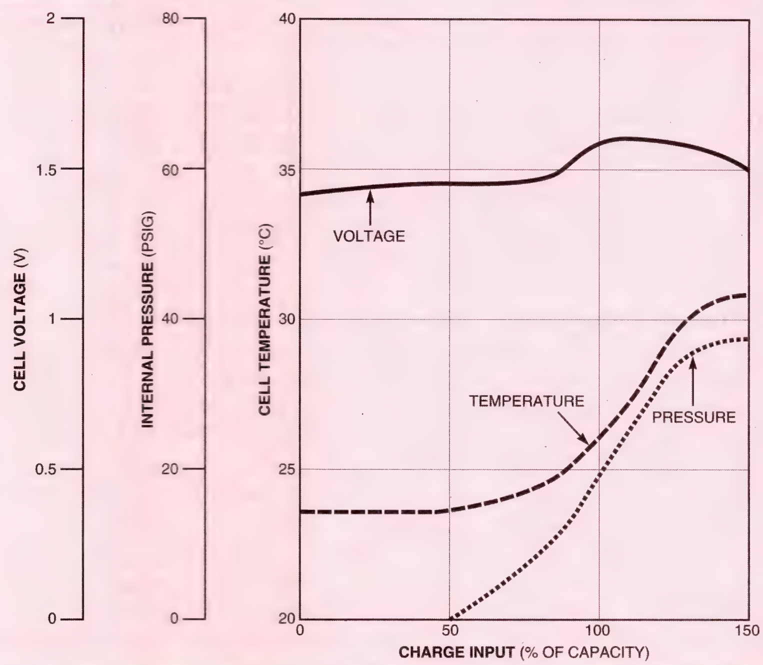
tions in the battery voltage as charging occurs. In particular, this method accurately detects and terminates charging at the "full-charge" inflection point at which dV/dt begins to decrease. Conventional slope-detection methods wait for zero or negative dV/dt, but by then the battery is in overcharge. This difference becomes particularly important when charging NiMH batteries.

Inflection analysis requires periodic sampling of the battery voltage. The Z8 smart-charging controller maintains a buffer that contains recent battery-voltage A/D readings. At each sampling interval, the Z8 calculates a new value of dV/dt and compares the result with previous values. To achieve repeatable results, A/D readings are taken with charging current turned off to minimize unpredictable IR drops. (The combination of dirty contacts and high charging currents causes unpredictable variations in battery-voltage readings, especially in the presence of shock or vibration.) Storing the A/D readings and using digital-processing methods further improves noise immunity. Should special system considerations exist, the software-based inflection-analysis technique is easily adjustable.

Log A/D conversion

A second patented Black and Decker innovation is a simple, cost-effective A/D technique that measures battery voltage. Since inflection analysis determines charge level by comparing slope values, it can use relative-voltage A/D readings instead of costly absolute A/D voltage methods. The patented A/D method uses Zilog's Z8 with onboard analog comparators and a small number of external components for A/D measurements (**Fig 6**). A resistive divider attenuates the battery voltage to within the Z8 comparator's common-mode input-voltage range. A resistor and capacitor generate a logarithmic reference voltage that is applied to the inverting input of the Z8's internal voltage comparator. A Z8 port pin either charges the capacitor in preparation for A/D measurement or discharges the capacitor during A/D conversion. An internal counter is initialized. The Z8 then starts the counter while

FIGURE 3



In a trickle charger, full-charge detection can be approximate. In fact, a low-current charger can charge batteries continuously until they are removed. In this case, the battery temperature and pressure are elevated above normal but will stabilize within the battery's design limits, causing little or no damage.

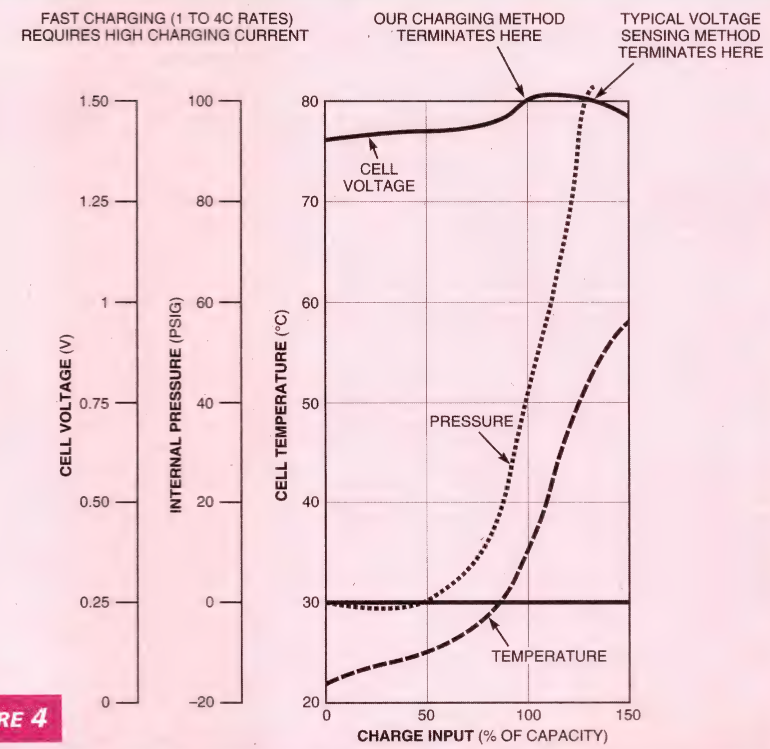


FIGURE 4

With fast charging, the battery's internal temperature and pressure increase dramatically if the high current continues after the battery reaches full charge.

FAST BATTERY CHARGERS

simultaneously commanding the external R-C network to start generating a falling logarithmic reference voltage for the comparator. When the falling R-C voltage crosses the scaled battery-voltage level at the other comparator input, a hardware interrupt stops the counter.

Thus, the counter value becomes a logarithmically scaled representation of the battery voltage. The counter value is stored in the A/D stack and is used (with the previous A/D readings) for slope calculations.

The log-A/D technique is inherently monotonic. It also normalizes slope calculations to accommodate a range of battery-pack voltages. Chargers designed for a fixed number of cells require only a two-resistor input-voltage divider. When the number of cells varies over a wider range, the Z8 adjusts the external attenuation network to perform autoranging. The addition of two resistors lets the circuit accommodate a 5:1 range in the number of cells. In this case, Z8 autoranging provides coarse adjustment of the initial A/D value within the converter's dynamic range. Each range allows sufficient A/D converter headroom for the expected change in battery voltage during charging.

Log A/D conversion simplifies the Z8 software. Consider the fact that the greatest change in battery voltage occurs when you bring a depleted battery to full charge. This gives the greatest start-to-finish voltage ratio (the worst-case condition in this discussion). Partially discharged batteries always exhibit a smaller start-to-finish voltage ratio. The worst-case start-to-finish voltage ratio is relatively constant for a given battery chemistry, and is thus predictable. Log A/D conversion transforms the start-to-finish voltage ratio in a given charging cycle into a constant algebraic difference. Similarly, you can easily compute any other percentage of change in battery voltage as the algebraic difference between the measured log A/D value and numerical constants used in the Z8's control program. Thus, the log A/D's normalizing property on battery-voltage measurements transforms the offsets and thresholds used in inflection analysis to easily adjusted fixed values.

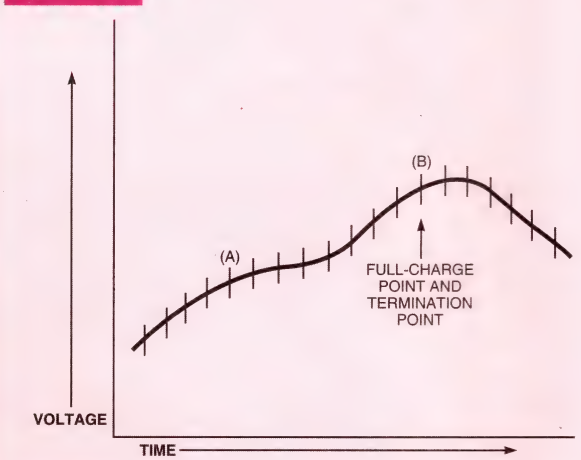
Other features of the charging controller

In addition to dV/dt-inflection analysis, the Zilog battery-charging controller uses conventional methods of full-charge detection as secondary charge-termination techniques. The software includes provisions for minus-slope, minus-delta-voltage, temperature-cutoff, and total-charging-time terminations. Slope analysis accurately terminates charging before the battery temperature increases appreciably. However, you may wish to use temperature cutoff as a safety provision to suspend charger operation if charger components become too hot, as would occur if the charger's cooling air flow were accidentally blocked.

The Zilog smart-charging controller performs a series of tests when it detects battery insertion. One proprietary feature of the Z8 software is a technique called fast full-charge detection (FFCD). Because a charged battery will not exhibit the inflection characteristic seen in a normal charge cycle, this method relies on NiCd impedance characteristics, which vary as a function of the battery's state of charge. This test allows the Z8 to quickly sense a fully charged battery and prevent overcharging. In addition, the Z8 measures battery impedance before charging commences. High-impedance batteries are charged with lower current to prevent damage.

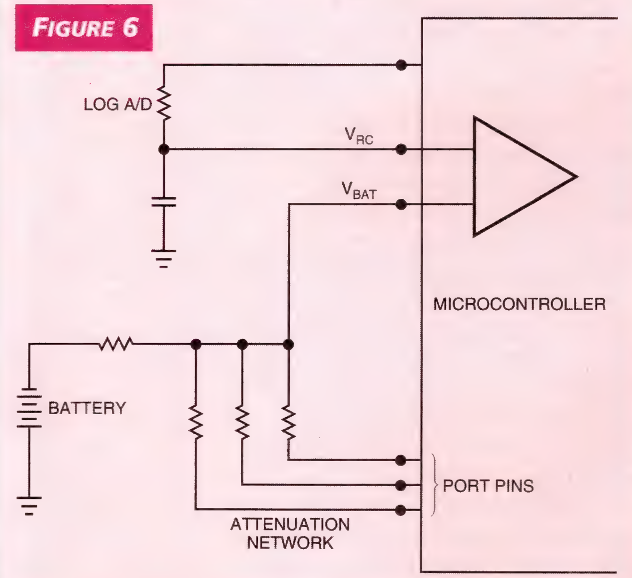
At the conclusion of a battery-charging cycle, the Z8 smart-charging controller reverts to an equalization mode in which very-low-current charging continues for a fixed time interval. This ensures that all cells in the pack charge fully. Inflection analysis is based on the overall dV/dt characteristics of the battery; individual cells within a pack will vary somewhat in their state of charge. An interval of low-current

FIGURE 5



If you sense the points at which the second derivative of the voltage vs time passed through zero during charging and terminate fast charging at the second of these inflection points, you will not overcharge the battery.

FIGURE 6



The Zilog/Black and Decker charger incorporates several additional innovations, including a logarithmic ADC and a switched attenuator controlled by a microcontroller port. This attenuator adapts the controller to work with battery packs containing different numbers of cells.

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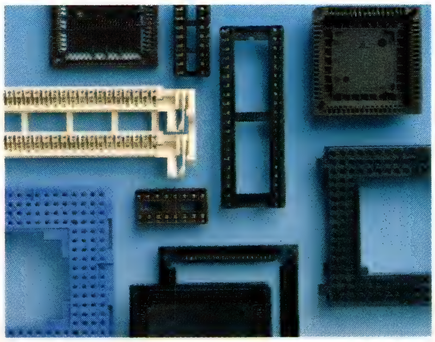

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CIRCLE NO. 47

AMP

charging ensures that all cells in the pack are topped off. At the conclusion of this equalization mode, the Z8 reverts to maintenance mode, which compensates for battery self-discharge by periodically applying a brief pulse of charging current. Thanks to this feature, batteries can remain in the charger indefinitely without losing charge.

The Zilog/Black and Decker smart-charging controller includes several other innovative features. A 9600-bps serial data output provides A/D readings, slope values, and other charging parameters to any external device configured to receive the data. Thus, external devices can use the Z8 as a charging monitor. To demonstrate this capability, Zilog provides diagnostic software that runs on IBM-compatible PCs. The program displays the charging battery's voltage graphically, in real time, and also displays other pertinent data.

Although this article deals mostly with NiCd batteries, inflection analysis also applies to NiMH, lead-acid, lithium-ion, and other rechargeable-battery chemistries. The various battery types exhibit differences in the shape of their dV/dt characteristics, but the inflections occur predictably. In lead-acid batteries, the second dV/dt inflection occurs at a predictable interval before the batteries reach full charge, but from the battery's Ahr capacity rating, you can easily derive the duration of the incremental charging needed to achieve full charge. The techniques discussed here make fast battery charging effective and inexpensive. Moreover, because they are based on software, the methods adapt easily to specialized requirements. EDN

Authors' biographies

Daniel Brotto is a project engineer for the US Power Tools group at Black and Decker Corp in Towson, MD. He has worked at Black and Decker for 14 years in electronics R and D and product development. His primary concentration is in the implementation of low-cost battery chargers, a field in which he has several patents pending. Brotto holds a BSCS from Loyola College, Baltimore.

Gary Cummings is president of Spectra Research, an engineering firm in Lake Forest, CA. He specializes in electronics design for consumer products and assists Zilog with system applications for Z8 microcontrollers. He received a BSEE from the University of Salt Lake City in 1976. He is a member of the IEEE.

James Goodhart is channel manager at Zilog Inc, where he has worked for four years. He is responsible for the Z8 microcontroller business, focusing on battery charging, infrared remote, and automotive applications. He attended San Jose State University and is a member of the Society of Automotive Engineers and the Joint Electron Devices Engineering Committee.

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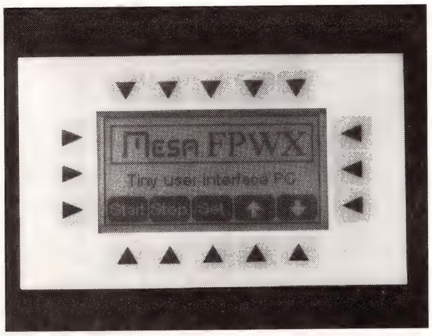
PowerPC motherboards suit high-volume products. The PowerPC-based Ultra and Atlas are low-profile and Baby-AT motherboards, respectively. They use a PowerPC 603 or 604 μP with 8 to 128 Mbytes of parity DRAM and a PCI local bus for I/O peripherals. Both chips implement the PCI bus, minimizing bottlenecks in moving data between memory and the peripheral controllers. The chips will be available in the fourth quarter for $1000 (1). **Motorola Computer Group**, Tempe, AZ. (602) 438-3481. **Circle No. 318**

PCMCIA card links desktops and portables. Outback, the newest member of the CardDock family of universal PC-card readers and writers, supports PCMCIA types I, II, and III cards. The rear-loading unit mounts into a 16-bit ISA AT slot, supports 5 and 3V PC cards, and both reads and writes 3.3V cards. It complies with PCMCIA version 2.0. $99 (1), $59 (OEM). **Greystone Peripherals Inc**, Los Gatos, CA. (408) 866-4739. **Circle No. 319**



Tiny, PC-compatible computer has graphics display. The PC-compatible FPWX includes an LCD graphics display in a thin, flat package measuring 2.6×4.5×1 in. The display has a 128×64-pixel monochrome, graphic, back-lit or reflective LCD. The CPU is a 9.2-MHz processor with 128 or 512 kbytes of system RAM, 128 or 256 kbytes of BIOS EPROM, and a socket for one 128- to 512-kbyte disk-emulator EPROM or flash EEPROM. A 64-pin PC-104 bus pinout-compatible header provides expansion. Adapters are available for ISA bus and PC-104 cards. The basic system with 128-kbyte RAM costs $249 (100). **Mesa Electronics**, Emeryville, CA. (510) 547-0837. **Circle No. 320**

Controller simultaneously drives true-color flat panels and high-resolution CRTs. The AV540 stand-alone flat-panel CRT controller drives flat-panel displays with up to 24 bits/pixel color depth and up to 1280×1024-pixel resolution. The board also drives a CRT simultaneously with resolutions up to 1024×768 pixels and 256 colors. An on-board dc/dc converter supports all display types, including TFT, single-scan STN, dual-scan STN, electroluminescent, and plasma flat panels. FRC and dithering generate more colors on a panel and reduce panel flicker. The controller supports direct input of 18-bit RGB data with hardware x-y or color keying to support live video windows on flat panels. A fully loaded board costs $299 (100). **AVED**, Tustin, CA. (714-573-5000). **Circle No. 321**

DRAM card holds 20 Mbytes. The JEIDA/JEDEC-standard 16-Mbyte, credit-card-sized IC DRAM cards expand the internal memory of a laptop from 4 to 20 Mbytes. The 88-pin cards operate as low as 3.3V with access times of 70 nsec. The cards can extend a laptop's battery life when applications access the card instead of directly accessing the machine's internal disk drive. $1070 (1000). **IBM Microelectronics**, Fishkill, NY. (800) 426-0181, ext 929. **Circle No. 322**

Keyboard connects to printer port. The full-sized Parallel Keyboard 101 connects to notebooks and subnotebooks via the printer port. By using a T connector, you can connect both the printer and the keyboard to the computer simultaneously. The keyboard consumes <1 mA, which has virtually no effect on the computer's battery life. You can customize the keyboard with special macros. A 102-key version is available for international use. $115. **Genovation Inc**, Irvine, CA. (800) 822-4333. **Circle No. 323**

Workstations use SuperSPARC. Two new SuperCompstation 20 desktop workstations use Sun's SuperSPARC chip set. Model 20A-50 uses a 50-MHz processor to deliver 69 SPECint92 and 78 SPECfp92 performance; the 60-MHz 20A-61 increases performance to 89 SPECint92 and 103 SPECfp92. Entry-level systems include a 2D/3D Turbo GX graphics accelerator, a 20-in. color monitor, and 32 Mbytes of RAM. Model 20A-50 includes a 520-Mbyte hard drive; Model 20A-61 has a 1-Gbyte drive and 1 Mbyte of super cache. From $12,500. **Tatung Science and Technology Inc**, Milpitas, CA. (408) 383-0988. **Circle No. 324**

Slide scanner increases digitizing speed. The SprintScan 35-mm slide scanner digitizes images at maximum resolution in 30 sec. The scanner scans in one pass, corrects color, and sharpens the image. Maximum output resolution is 2700 dpi. The scanner accepts color and black-and-white, 35-mm transmissive film, including positive and negative and mounted or unmounted transparencies and film strips. It has a standard SCSI-2 interface. $2500. **Polaroid Corp**, Cambridge, MA. (800) 662-8337. **Circle No. 325**

PCMCIA card provides parallel I/O. The IOP-241 PCMCIA card allows parallel communication between PCs and external devices. It provides up to 24 digital I/O signals, each of which can be configured as input or output. Each of the 24 signals are buffered, to enhance the card's drive capability and can be used as interrupt sources. The card complies with PCMCIA version 2.1 and plugs into Type II PCMCIA sockets. $229. **Quatech**, Akron, OH. (216) 434-3154. **Circle No. 326**

Computers put Pentium in industrial package. The StealthRack Pentium PCs put 60- and 66-MHz Pentium processors in rugged packages. The systems offer RAM expansion of up to 64 Mbytes, disk drives from 200 Mbytes to 2.1 Gbytes, and seven full-length expansion slots, including three with the VESA local bus. Other options include dc operation, tape backup, CD-ROM, PCMCIA, and redundant power supplies. The system's main board incorporates I/O, IDE, SCSI, and floppy controllers. From $3200. **Stealth Computer Corp**, Toronto, ON, Canada. (416) 674-3800. **Circle No. 327**

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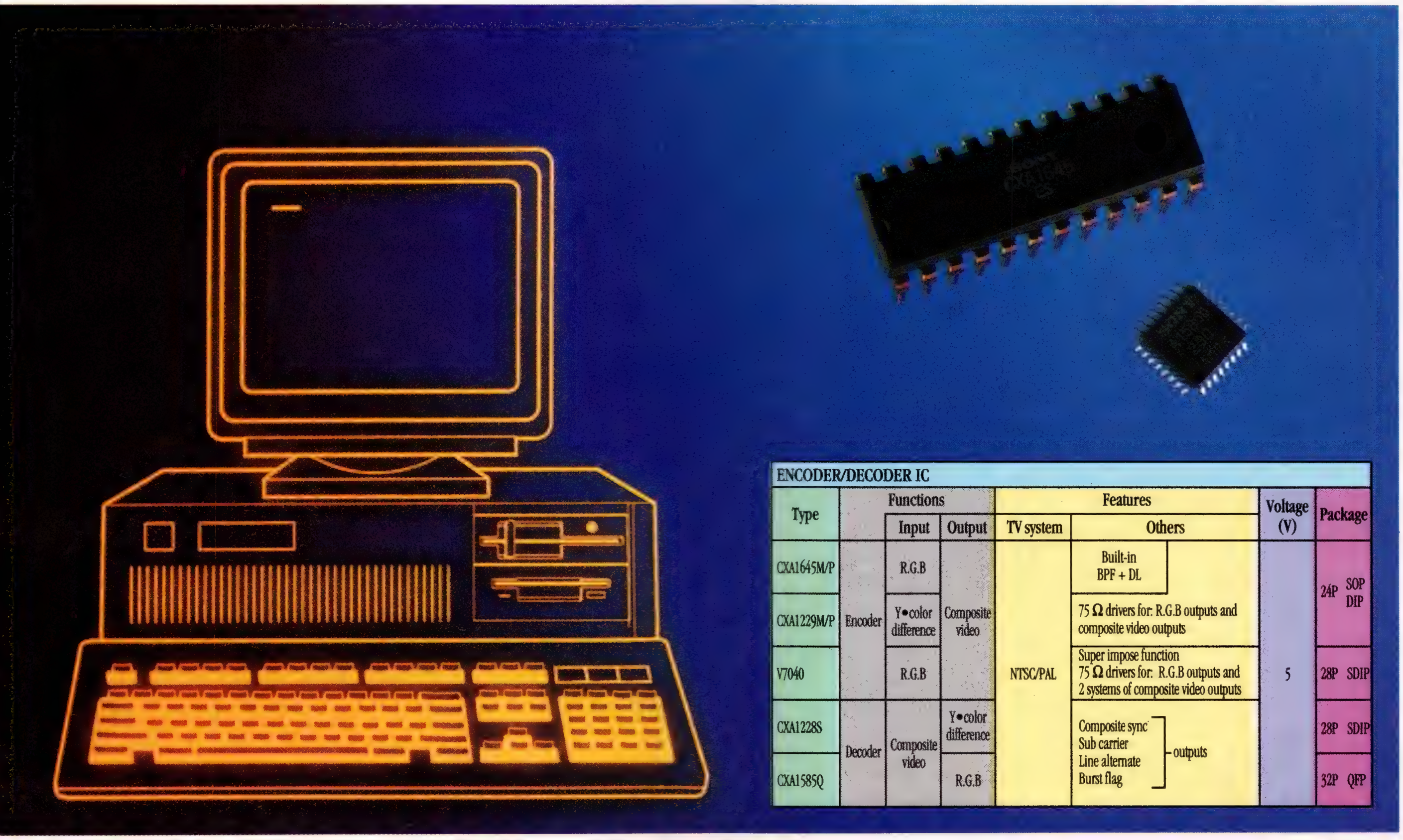

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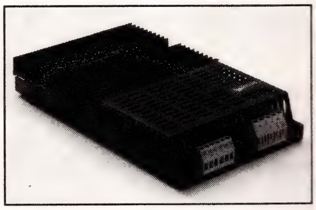
PCMCIA power controller replaces forest of MOSFETs. The MIC2560 is a PCMICA-slot power controller that manages the profusion of both main-supply and programming voltages. The controller's 16-pin surface-mount package fits between a PCMCIA controller and a PCMCIA socket, replacing six to 10 MOSFETs and associated glue logic. The device's outputs are short-circuit- and overvoltage-protected. $2.96 (1000). **Micrel Semiconductor**, San Jose, CA. (408) 944-0800. **Circle No. 342**

DC/DC converter models second-source AT&T FW series. The 150W PKU 4111 PI and the 100W PKU 4110 PI are single-output, 5V dc/dc converters. The units accept 36 to 72V dc. The converters have the same pinouts as AT&T's FW series but offer a smaller footprint, and they operate to 100°C with optional heat sinking. Unlike most such board-mounted, high-power converters, these units are not potted; their metal cases' sides have perforations, allowing cross ventilation, even with optional heat sinks mounted. $146 (100). **Ericsson Components Inc**, Richardson, TX. (214) 997-6561. **Circle No. 343**



Switching power supplies get enhanced. The FlatPac family of modular off-line switching power supplies now features an autoranging input, module-disable inputs, and compliance with VDE and FCC EMI regulations. The switchers integrate one, two, or three of the maker's dc/dc converters in a single chassis. The factory assembles the switchers to user specifications. $0.85/W in OEM quantities. **Vicor Corp**, Andover, MA. (508) 470-2900. **Circle No. 344**

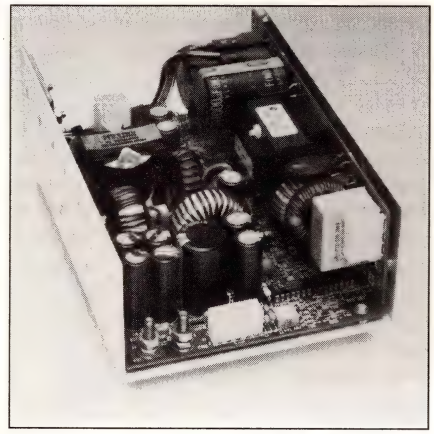
10W dual-output dc/dc converter measures 1×2×0.4 in. The SR series of 10W dc/dc converters features 81% efficiency max. The converters accept 12, 24, or 48V dc. Outputs are ±5, ±12, or ±15V. Noise is 70 mV p-p from 0 to 20 MHz typ. The converters work from –40 to +85°C. $43.99 in OEM quantities. **Calex Mfg Co Inc**, Concord, CA. (510) 687-4411. **Circle No. 345**

Charger handles NiCd, NiMH, and lead-acid batteries. The Gang Charger simultaneously recharges from one to eight battery packs containing NiCd, nickel-metal-hydride (NiMH), and sealed lead-acid battery packs from a wall outlet. $30 in OEM quantities. **Venture Technologies Inc**, North Billerica, MA. (508) 667-9890. **Circle No. 346**

External ac/dc power supplies come with optional NiCd charger. Single-output, 25W versions of the CL family of external 25 and 40W ac/dc switching power supplies come with an optional NiCd-battery-charging circuit. The supplies accept 90 to 264V ac at frequencies ranging from 47 to 440 Hz. Outputs are ±5, ±12, 9.5, 24, or 48V dc. The switchers meet FFC, UL, CSA, VDE, and BABT EMI and safety standards. 25W models cost $35 to $40, and 40W models cost $55 in OEM quantities. **Computer Products/Power Conversion America**, South Boston, MA. (617) 268-1170. **Circle No. 347**

DIP-sized dc/dc converters accept wide input-voltage range. The TWB series of 24-pin DIP-sized dc/dc converters accepts 9 to 36V dc or 18 to 72V dc. The series outputs are 5, 12, 15, ±12, or ±15V. The converters have input π filters. The devices measure 0.8×1.25×0.40 in. and have 500V isolation. $15.85 in OEM quantities; delivery, stock to four weeks ARO. **Polytron Devices Inc**, Paterson, NJ. (201) 345-5885. **Circle No. 348**

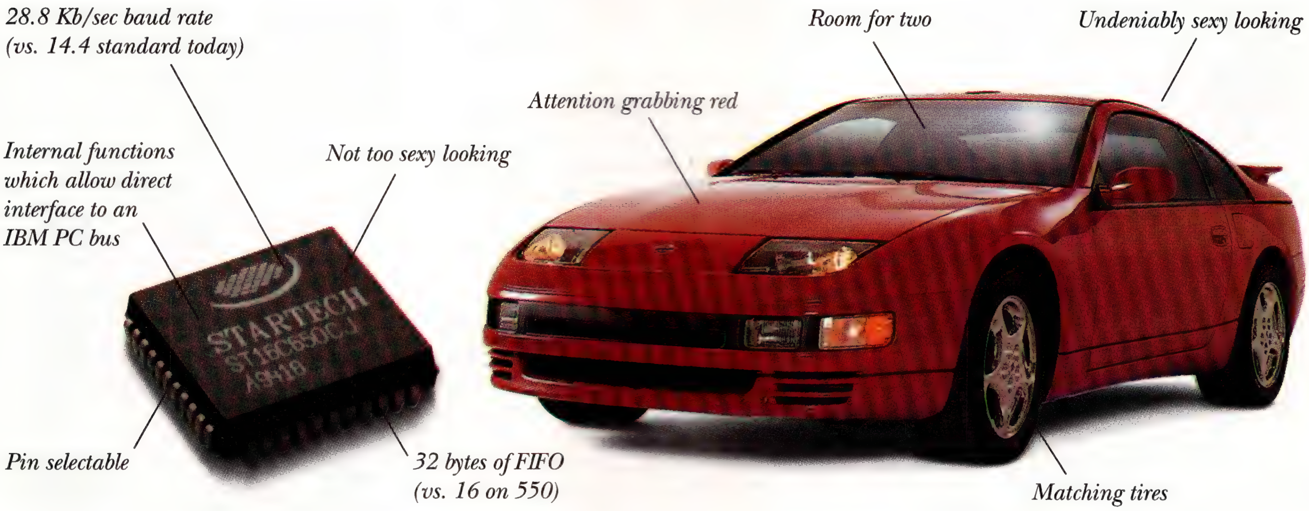
DC/DC converters have 2000V isolation. The 2001 series of single- and dual-output 5W dc/dc converters have 2000V (5000V pk) input/output isolation. The units are UL 1950 and CSA 22.2 approved. Four models operate from 5 or 12V dc inputs, providing –9 or +5 and +10V-dc outputs. The supplies measure 1.30×1.30×0.375 in and operate over –30 to +75°C. $36 to $40 (100); delivery is stock to four weeks ARO. **Conversion Devices Inc**, Brockton, MA. (508) 559-0880. **Circle No. 349**



375W supplies stand 2.5 in. tall. The 124 series of low-profile, 375W supplies measures 5×7×2.5 in. The supplies accept 94 to 264V ac. All models meet UL, CSA, TUV, and BABT requirements. Outputs are +5V at 35A, +12V at 10A, –12V at 0.5A, and –5V at 0.5A. $225 (1000); delivery, stock to eight weeks. **Conversion Equipment Corp**, Orange, CA. (714) 637-8654. **Circle No. 350**

AC front-end power distributed converters. The PM33210P isolated (3000V) front end provides as much as 2.1 kW (48V at 48A) to distributed "brick" converters. You must power the unit from 180 to 264V ac to achieve 2.1-kW performance (1.2 kW from 85V ac). The supply measures 5×5×11.5 in. and is hot-swappable. The supply's active power-factor correction meets IEC 555-2. The unit also meets UL, CSA, and TUV requirements. $795 (50). **Pioneer Magnetics**, Santa Monica, CA. (310) 829-6751. **Circle No. 351**

Both are turbos with a V6 engine, but the one on the left will launch the next generation of modem devices.



Startech's Turbo 16C650

Imported Sports Car

Startech's new ST16C650 is going to help drive the next generation of modem devices. And while on the outside it may not look as flashy as an imported sports car, on the inside it is far more remarkable.

Compatible in footprint to our older 550, it is the first and only UART product to offer all of the following features in combination.

It has a 28.8 kb/sec baud rate, compared to today's standard of 14.4. It has 32 bytes of FIFO, compared to today's 16. Its internal functions allow direct interface to an IBM PC bus. It is pin selectable and has reduced software overhead thanks to Xon/Xoff handshaking. And it has a sleep mode that lets the chip power down automatically when there's no communication.

For more information on how the new ST16C650 can help launch your advanced modem products, or evaluation boards on all of our products, call (800) 245-6781 or fax us at (408) 745-1269.

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CIRCLE NO. 111

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1-Mbit slow SRAMs have 64k×16-bit organization. The ultralow-power MCM51016ALL SRAM draws a maximum standby current of 10 μA from a 3V power supply. The MCM51016AL draws 50 μA max standby current. Both devices draw a maximum of 100 mA of active current. The devices can hold data when the power supply drops to 2V, and they offer 70-, 85-, or 100-nsec access times. The devices come in a 44-pin standard or reverse-pinout TSOP. $15.75 (10,000). **Mitsubishi Electronics America Inc**, Sunnyvale, CA. (408) 730-5900. **Circle No. 328**

8-bit ADC takes 600M samples/sec. The TDA8718 samples at rates up to 600M samples/sec while maintaining an effective 8-bit signal bandwidth of 100 MHz. Power dissipation is 1.14W. The ADC's wide-bandwidth analog-input stage reduces the input capacitance to 5 pF and eliminates the need for S/H circuitry for input signals up to 150 MHz. Both the ends and center point of the on-chip reference ladder are available on package pins so that you can easily set digital zero and digital full scale using an external reference current and external resistors. The digital outputs are ECL-100k compatible. Around $360 (10,000). **Philips Semiconductors**, Sunnyvale, CA. (408) 991-2101. **Circle No. 329**

Regulators produce clean PCMCIA voltages. The LT1312 single and LT1313 dual regulators power and protect the VPP pins of standard PCMCIA card slots. Built-in current limit and thermal shutdown ensure that a short on either side of a standard socket doesn't damage the host computer or PC card. The regulators produce 0, 3.3, 5, and 12V and high-impedance outputs from any unregulated 13 to 20V supply, thus eliminating the need for an extra 12V regulator to generate clean VPP power. Quiescent current is 30 μA for the single and 60 μA for the dual regulator when you program them for the 0V or high-impedance modes. A single 1-μF capacitor is the only external component required. In 8- and 16-pin SOICs, respectively, the LT1312 costs $2.03, and the LT1313 costs $3.03 (1000). **Linear Technology Corp**, Milpitas, CA. (800) 454-6327. **Circle No. 330**

Data compression as fast as 40 Mbytes/sec. The ALDC1-20S and 40S adaptive lossless data-compression chips allow 20- and 40-Mbyte/sec processing. The chips provide data-compression ratios greater than 2 to 1 in real time. The devices support multiprotocol DMA interfaces, industry-standard μP interfaces, eight/16 selectable data buses with selective parity checking, and 16-byte FIFO buffering and bypass mode. Both devices employ a 5V, 0.8-μm CMOS process. The ALDC1-20S sells for $38.30 (10,000). The ADLC1-40S sells for $70.20 (10,000). **IBM Microelectronics**, Hopewell Junction, NY. (914) 892-5389. **Circle No. 331**

Bus drivers designed for automotive diagnostics. The Si9241EY and Si9243EY narrow-body, small-outline bus drivers meet the ISO 9141 standard for communications between computers and diagnostic equipment. The series drives high capacitive loads, as defined by the ISO 9141 specification. In automobiles and external equipment, the devices replace as many as 20 discrete parts with an SO-8 package. $0.89 for the Si9241EY and $1.05 for the SI9243EY (OEM quantities). **Siliconix Inc**, Santa Clara, CA. (800) 554-5565, ext 29. **Circle No. 332**

Encryption processor integrates DMA. Using two high-speed data-encryption-system engines, the RoadRunner284 cipher path processor provides a ciphering bandwidth of 284 Mbps. It also provides an I/O bandwidth of 640 Mbps using DMA controllers with FIFO buffers. The 208-pin device includes user-definable ROM and RAM and operates at a clock speed

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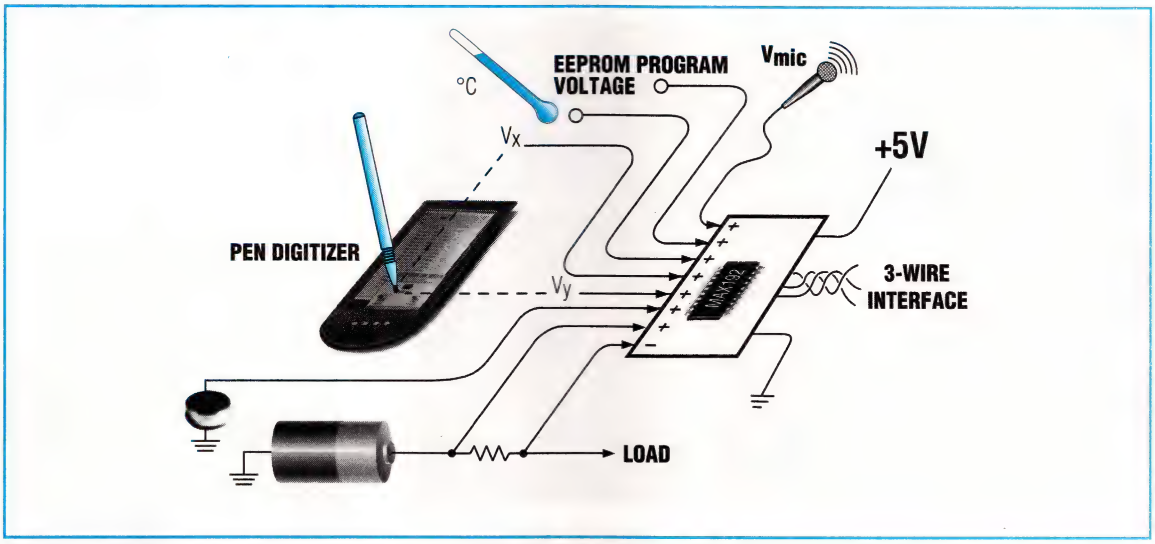
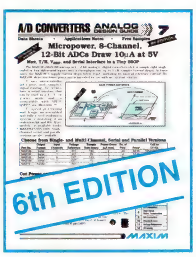


Eight analog inputs are independently programmable for differential or single-ended, unipolar or bipolar signals via the serial interface.



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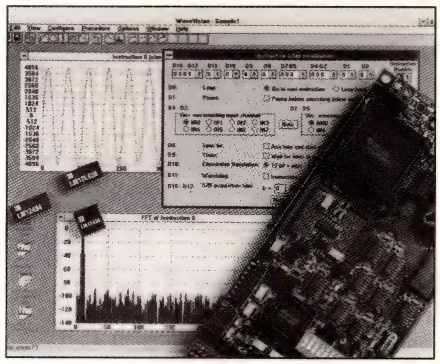
CIRCLE NO. 159

of 40 MHz. It costs $75 (10,000). **Semaphore Communications**, Santa Clara, CA. (408) 980-7750. **Circle No. 333**

Frequency synthesizers target cellular and cordless standards. The SA7025 and SA8025 fractional-N dual-frequency synthesizers integrate a high-frequency prescaler with a fractional-N PLL synthesizer on a single chip. These ICs target the North American IS-54 and Japanese PDC-800 standards. The 7025 provides coverage to 1 GHz, and the 8025 operates to 2 GHz. Both include an auxiliary 150-MHz synthesizer to create offset frequencies or a fixed second local-oscillator signal. To switch quickly from channel to channel without excessive phase noise, the ICs implement adaptive filtering with a programmable speed-up mode that uses two filter designs with different charge-pump currents. In 20-pin SSOPs, the 7025 and 8025 cost $6.50 and $8 (1000), respectively. **Philips Semiconductors**, Sunnyvale, CA. (800) 447-1500, ext 3012. **Circle No. 334**

Low-dropout regulators work at 3.3V. The LP2952-3.3 and LP2953-3.3 deliver 250 mA of output current while exhibiting dropout voltages of 470 mV at full load. Quiescent current is 130 μA at a load of 1 mA. Both regulators have a 3.3V voltage tap that lets you set the 3.3V output without using external resistors. Both devices also include an electronic shutdown pin, which you can use to reduce current to a maximum of 140 μA. An error flag indicates when the regulators have fallen out of regulation by more than 5%. The LP2952 comes in 14-pin DIPs and 16-pin SOICs; prices start at $2. The LP2953, which includes an auxiliary comparator, comes in 16-pin DIPs and SOICs; prices start at $2.30. **National Semiconductor**, Santa Clara, CA. (408) 721-7509. **Circle No. 335**



Data-acquisition systems have flexible serial interface. The LM12434/8 and LM12L438 12-bit ICs don't require any glue logic to connect to nearly all popular μPs. They are directly compatible with Microwire/PLUS, SPI/QPSI, the TMS320 family, 8051s, and the I²C interface for true two-wire serial communications. These devices combine an analog front end—four- or eight-channel input multiplexer, 12-bit plus-sign ADC with S/H, single-ended or differential inputs—with numerous digital features—an 8-word instruction register, a 16-bit programmable timer, and a FIFO buffer. A shutdown mode drops typical power consumption to 25 μW at 5V. The devices come in 28-pin PLCCs or SOICs, and prices range from $16.60 to $18.90 (1000). A design kit costs $195. **National Semiconductor**, Santa Clara, CA. (408) 721-5831. **Circle No. 336**

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		CONV. RATE (MSPS)	INTERNAL T/H?	50Ω INPUT	EFFECTIVE BITS	SINAD (dB @ F_{IN})	INPUT BW (MHZ)	JITTER (pS)	INPUT CAP (pF)
Maxim	**MAX101**	**500**	**Yes**	**Yes**	**7.1**	**43 @ 250MHz**	**1200**	**< 2**	**< 2**
Maxim	**MAX100**	**250**	**Yes**	**Yes**	**7.1**	**44 @ 125MHz**	**1200**	**< 2**	**< 2**
Harris	HI1276	500	No	No	5.8	37 @ 100MHz	300	11	20
Sony	CXA1276K	500	No	No	6.4	40 @ 100MHz	500	5	16
SPT	SPT7750	500	No	No	6.3	40 @ 250MHz	900	2	15

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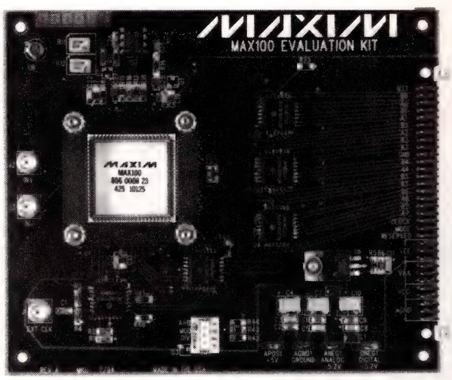
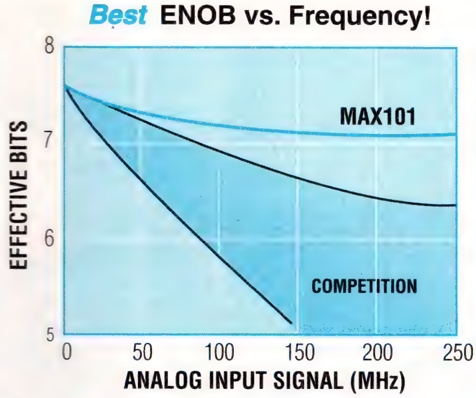
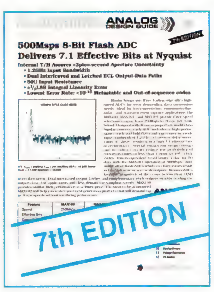


Best ENOB vs. Frequency!





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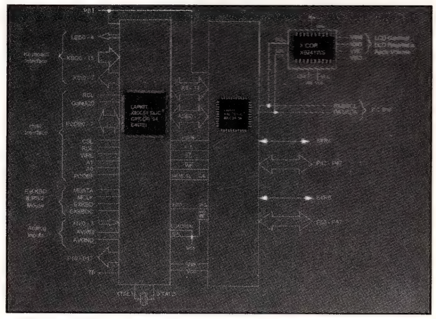
CIRCLE NO. 160

DSP chip provides telecommunications. The TMS320C57 includes a C5x series DSP CPU, onboard memory to implement digital cellular telephone standards, and two intelligent peripherals—a buffered serial port and a host processor interface. A 3V process allows the device to run at a sustained throughput of 40 MIPS. The device offers a 5-μA standby current, 32-kbyte ROM, and 7-kbyte RAM. The buffered serial port has a 2k-word buffer that lowers the chip's overhead by eliminating the need to service real-time data interrupts from the system's A/D and D/A converters. A 128-pin TQFP costs $33. **Texas Instruments Inc**, Denver, CO. (800) 477-8924, ext 4500. **Circle No. 337**

Interface IC connects four E1 channels. The XR-T5794IJ contains four sets of CCITT G.703-compliant drivers and receivers, as well as associated diagnostic functions in a 68-pin PLCC package. With all transmitters on, the CMOS IC dissipates a maximum of 680 mW while sending all ones. You can power down each transmitter individually. Putting line-side bipolar outputs into high-impedance mode allows hot-swapping of line cards in systems. The receivers exceed G.703 cable-loss, interference-margin, and return-loss specifications. The IC also contains a fifth G.703 driver for channel monitoring and testing. $29.71 (1000). **Exar Corp**, San Jose, CA. (408) 434-6400. **Circle No. 338**



Chip set integrates keyboard and power-management controller. The LapKit provides keyboard control, display control, and power management of laptop computers. The device contains two of the company's E² devices and an Intel μC. The set is preprogrammed with a Phoenix Technology-compatible keyboard BIOS and an Intel 80C51SL μC, which features a keyboard controller for an 8042-based host interface. A 5V version costs $22.33, and a 3V version costs $25 (10,000). **Xicor Inc**, Milpitas, CA. (408) 432-8888. **Circle No. 339**

High-side driver turns μP power on and off. The L9820 drives inductive or resistive loads with one side connected to ground. An internal DMOS power-output transistor has an on-resistance of <800 mΩ and delivers 300 mA of continuous current and 1.5A peak current. A TTL-compatible input controls this output stage. Protection circuits guard the IC against damage from short circuits, junction overtemperature, and overvoltage conditions by disabling the output stage and informing the μP through a diagnostic output. The IC draws 4 mA in the on state and <300 μA—typically 130 μA—in the off state. In 8-pin DIPs and SOICs, the device costs around $1 (OEM). **SGS-Thomson Microelectronics**, Lincoln, MA. (617) 259-0300. **Circle No. 340**

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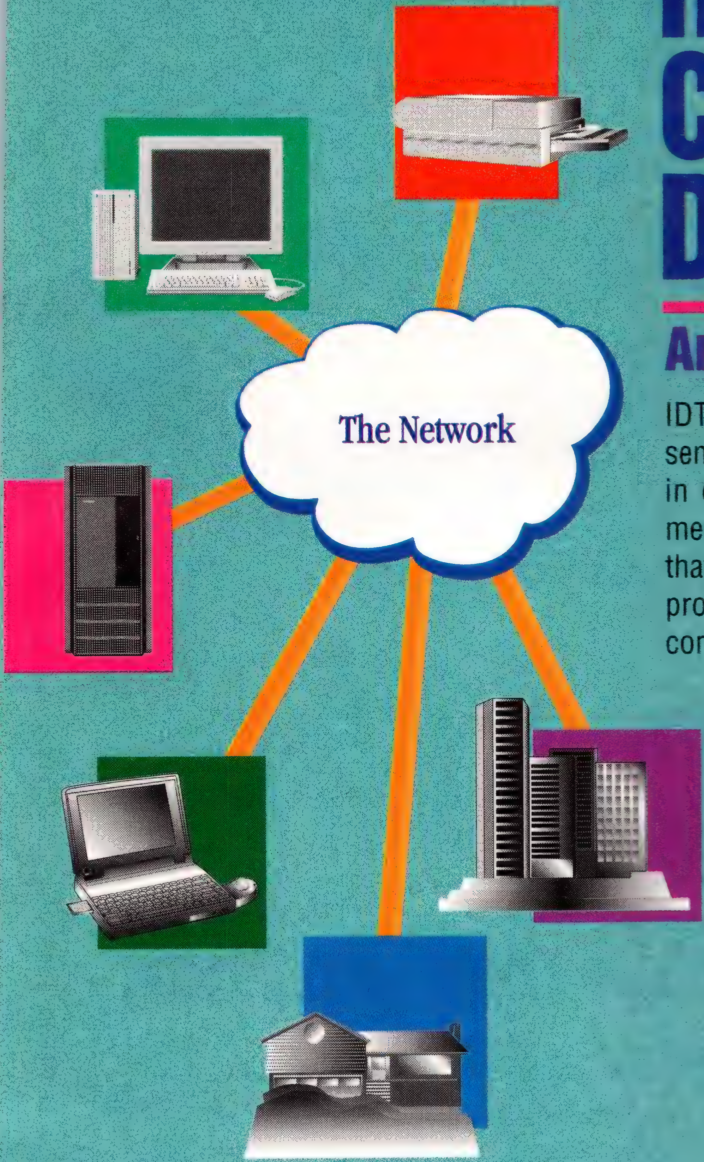

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I. **IDT ICs for Datacom Systems**

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- Low-cost ATM interface card using a new SAR IC
- FIFOs and Multi-Port Memories in ATM switches

III. **Routers**
- An Ethernet-to-ATM router design
- Using Orion™ in a high-performance bridge/router
- A router for mixed voice and data traffic

IV. **Portable Applications**
- Components for PCMCIA cards
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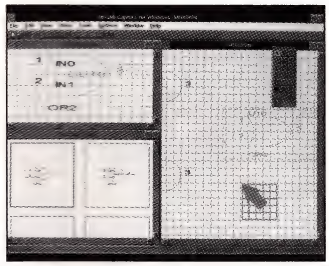
Circle No. 427

Low-cost tool lets you draw and analyze timing diagrams. Timing Diagrammer lets you draw and analyze timing diagrams for violations. You can specify delays that force relative transition times between signals, setup-and-hold times that monitor the time between two signal transitions, and create spreadsheets for editing timing parameters. The timing parameters can be mathematical expressions containing variables. The tool runs on PCs under Windows 3.1 and costs $249.99. **SynaptiCAD**, Blacksburg, VA. (703) 953-3390.
Circle No. 428

Optimizer speeds fixed-point DSP designs. The upgraded version of Signal Processing WorkSystem adds the Fixed Point Optimizer option. The option determines the number of bits needed in a fixed-point word to meet a system specification, such as S/N ratio. You can also start a design with floating-point behavioral design and generate the fixed-point behavioral design. The optimizer works with virtually any design, including time-varying, multirate, and nonlinear systems in wireless and multimedia applications. The Fixed Point Optimizer will be available in the third quarter, and prices start at $20,000. **Alta Group**, Foster City, CA. (415) 574-5800.
Circle No. 429



PC-based electronic-design-automation-tool supplier moves to Windows. OrCAD is making all its design tools available on Design Desktop for Windows. Capture for Windows, the company's schematic-capture tool, will be available by the end of November. The company expects the remainder of its tools to be available under Windows by year-end. Capture for Windows will cost $995, with discounts available for existing customers. **OrCAD**, Beaverton, OR. (503) 671-9500.
Circle No. 430

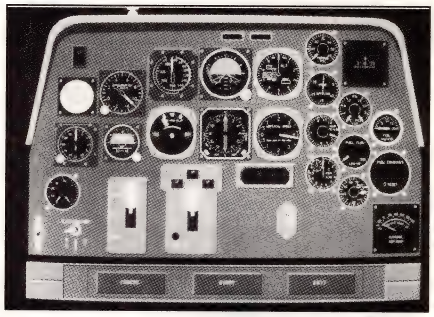
FPGA design kit for Actel units improves performance of synthesized designs. This field-programmable gate-array (FPGA) design kit supports Synopsys' FPGA Compiler 3.1, DesignWare microcells, and VHDL System Simulator. Using the kit with FPGA Compiler 3.1 provides a performance improvement of up to 80%, the company claims. A graphics coprocessor design, including data-path and arithmetic functions, operates at 43 MHz, a 78% improvement over the

previous design kit and compiler versions. The design kit costs $4995 and will be available in September. **Actel Corp**, Sunnyvale, CA. (408) 739-1010. **Circle No. 431**

Mixed-signal simulator offers native analog and VHDL simulation. The VHDeLDO analog and digital simulator comprises the company's HDL-D VHDL simulator, and HDL-A, a VHDL-based analog simulator. The simulator lets you use behavioral models for both analog and digital systems components. Prices for VHDeLDO start at $35,000. **Anacad EES**, Milpitas, CA. (408) 954-0600. **Circle No. 432**

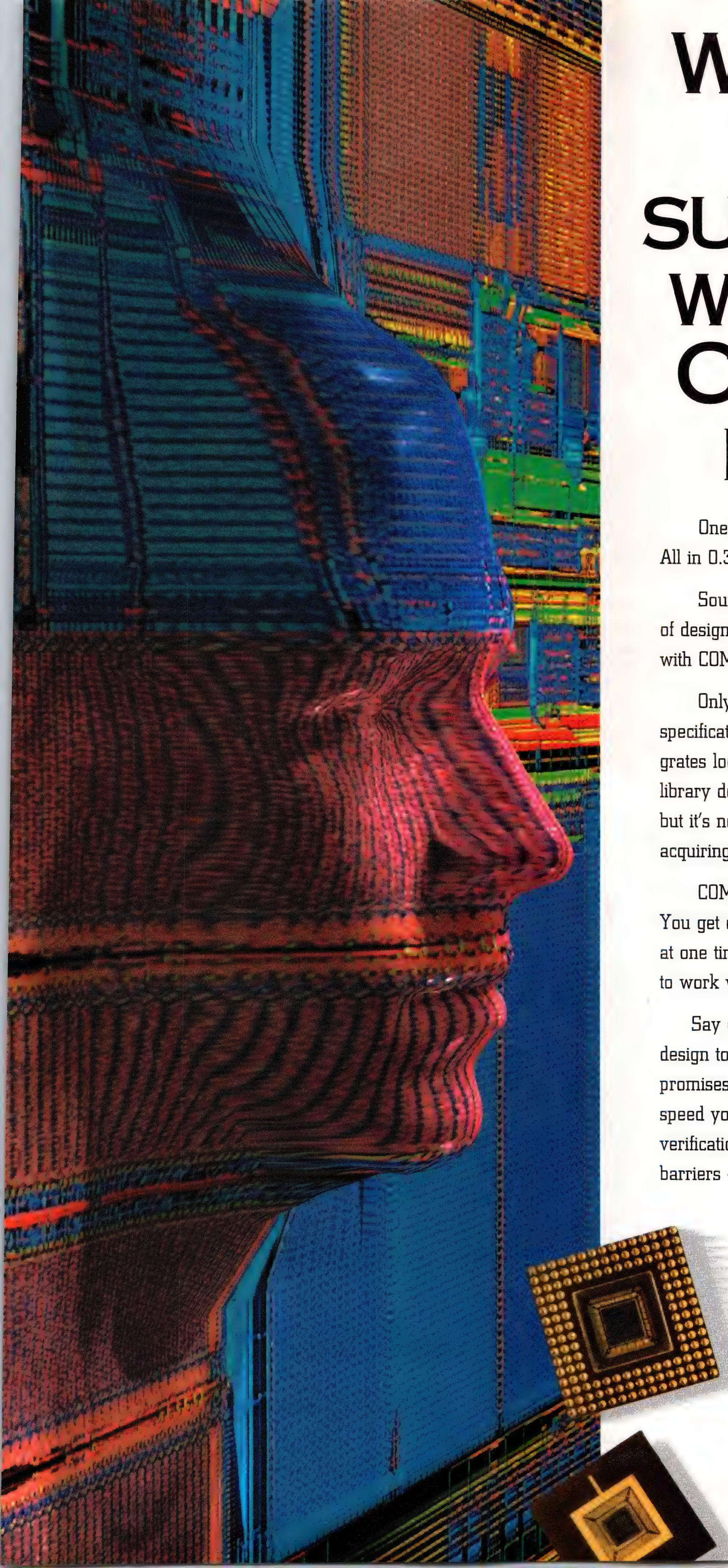
Active-filter design tool runs on PCs. The AFDPLUS design tool helps you design lowpass, highpass, bandpass, band-reject, and allpass filters. The tool provides mathematical-filter characteristics including Butterworth, Chebychev, Elliptic, Bessel, and Gaussian, plus more exotic behaviors, such as Papoulis and Catenary responses. The software also provides PLL analysis. AFDPLUS 3.0 costs $995. **Webb Laboratories**, Brookfield, WI. (414) 367-6825. **Circle No. 433**

Tool links corporate component database with schematic capture. PROdatabook is a PC-based component data-entry and -verification tool that links schematic capture with component databases. The tool costs $1495 for a single user and $14,995 for a site license. **Viewlogic Systems Inc**, Marlboro, MA. (508) 480-0881. **Circle No. 434**



Prototype real-time graphical human-machine interfaces. VAPS 3.1 provides a set of tools to help you build real-time graphical human-machine interfaces. In addition to helping you create a prototype, the VAPS C code generator translates the graphical prototypes, including animation properties, interactive behavior, and connections into executable C code. You can integrate the generated C code with real-time kernels. VAPS runs on workstations, and prices start at $16,500. The company plans to introduce a version for Windows in the fall. **Virtual Prototypes Inc**, Montreal, PQ. (514) 341-3874. **Circle No. 435**

Specify and analyze pc-board and multichip-module layout constraints. EngineerView lets you define and analyze topology-based electrical rules early in a design. In addition to setting up rules that constrain the physical layout, you can also perform initial placement of critical components on the board using an interactive timing-driven placement capability. EngineerView is scheduled for fall availability and costs $49,500. **Mentor Graphics**, Wilsonville, OR. (503) 685-8000. **Circle No. 436**



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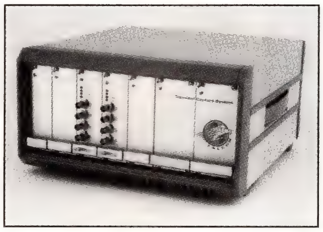
Windows-based software simplifies acquiring data from meters and counters. The 34812A BenchLink/Meter package lets you transfer data from HP DMMs and counters to your PC without writing code. The software transforms the 34401A DMM and the 53131A, 53132A, and 53181A counters into single-channel data-acquisition systems. $150. **Hewlett-Packard Co**, Santa Clara, CA. (800) 452-4844.
Circle No. 352

$395 data-acquisition boards take 100k samples/sec. The two-thirds-length PCI-20428W-1 and -2, which plug into the 8-bit ISA bus, both offer 16 input channels, 12-bit resolution, a programmable-gain amplifier, two DAC outputs, eight TTL inputs, eight TTL outputs, a counter/timer, and two-channel DMA. The -1 version offers gains of one, 10, and 100; the -2 version offers gains of one, two, four, and eight. **Intelligent Instrumentation**, Tucson, AZ. (602) 623-9801.
Circle No. 353

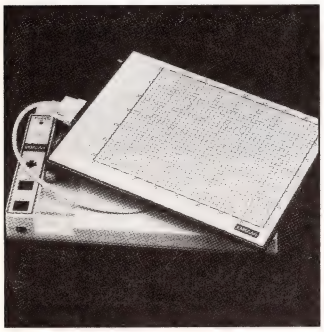


Transient data recorder captures 1M samples/channel at up to 2M samples/sec. The modular Falcon system works with PCs running MS Windows. The vendor supplies the system with or without the PC. You can choose among 12-bit ADC modules: A module that takes 2M samples/sec/channel contains four simultaneous-sampling ADCs. One type of 25k-sample/sec/channel unit has 32 simultaneous-sampling ADCs; a second has 64. Mainframes accept up to eight modules; systems can include several mainframes. The unit captures pretrigger or post-trigger data. Triggering is under control of an external timebase or an internal programmable crystal clock. Without a PC, an eight-channel, 2M-sample/sec system costs $16,250; four-channel, 2M-sample/sec modules cost $4445. **Sunnyside Systems Inc**, Tucson, AZ. (602) 742-0755.
Circle No. 354

VXIbus slot-0 controller ships with MS-DOS V6.2. The VXI-5543D ($5250) is a two-slot, C-size VXIbus module based on an i386SL µP. The module includes three RS-232C/RS-485 ports (two of which operate to 115.2 kbps), a bidirectional printer port, a VGA video port, a bus-mouse port, a $3^1/_2$-in. floppy-disk drive, a 240-Mbyte hard-disk drive, and a 1-Mbyte solid-state disk for program storage. The standard 4-Mbyte RAM expands to 10 Mbytes. Besides MS-DOS, software installed on the hard disk includes an interactive system monitor, ANSI-compatible C-language driver libraries, and sample programs. **ICS Electronics Corp**, Milpitas, CA. (408) 263-5500.
Circle No. 355

6U VMEbus board houses 16 delta-sigma ADCs, 16 DACs, and eight C40 communications ports. The Model 4625 divides its inputs and outputs into four groups, each of which has its

own sample-rate generator whose frequency you can set from 4 to 48 kHz with 32-bit resolution. Each group can operate in A/D, D/A, or combination modes and can use one or two C40 ports. The ADCs feature amplifiers whose gain is programmable from 0 to 22.5 dB in 1.5-dB steps. The DACs include attenuators programmable from 0 to 94.5 dB in 1.5-dB steps. The ADCs operate as 16-bit linear devices or as 8-bit A- or μ-law encoders. $4995; delivery four to six weeks, ARO. **Pentek Inc**, Norwood, NJ. (201) 767-7100. **Circle No. 356**



Scanner maps pc boards' EMI emissions and susceptibility. EMSCAN uses spectral and spatial scans to locate and quantify 10- to 750-MHz near-field emission sources on boards as large as 9.6×12 in. The system also performs susceptibility testing by mapping the flow of injected RF currents. Besides the scanner, which contains 1280 current probes spaced 0.3 in. apart, the system includes a power supply, an IEEE-488 interface, and Windows-based software, which controls scanning, data storage, and data retrieval, and aids in evaluating test results. $47,000; delivery, six weeks, ARO. **Amplifier Research**, Souderton, PA. (215) 723-8181. **Circle No. 357**

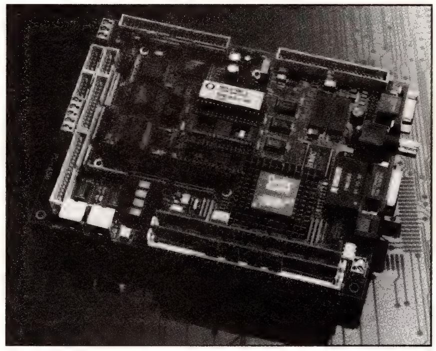
EISA bus IEEE-488.2 controller transfers data at over 7.5 Mbytes/sec. The EISA-GPIB board, which is based on the vendor's TNT4882C controller ASIC, supports the vendor's HS488 protocol. Using the protocol, the board can transfer data to or from devices on the bus at speeds >7.5 Mbytes/sec. The vendor's NI-488.2 driver software package for MS-DOS and Windows accompanies the board. $595. **National Instruments Corp**, Austin, TX. (512) 794-0100. **Circle No. 360**

PCMCIA card diagnoses faults in PC-card interfaces. With the BGM64, which plugs into a PCMCIA slot, you can wrap the data and address buses through a PCMCIA interface and check them for opens and shorts. Host software allows testing of all 16 bits in an emulated 64-Mbyte address space. Because no 64-Mbyte solid-state memory cards exist, you can easily overlook testing the upper reaches of the address space. The card also tests the power supplies to make sure that they can handle the loads they should be able to drive. $249; developers kit, $4500. **Boca Technology Group**, Boca Raton, FL. (407) 750-1528. **Circle No. 358**

Tester takes 3 sec/Mbyte to verify 100% of RAM-module function seven ways. Sigma LC is a low-cost version of Sigma 2, which the vendor claims is the most popular test system among US third-party SIMM manufacturers. The Sigma LC can test four 30-pin memory modules simultaneously. This configuration mimics that of most PCs. According to the vendor, there is no reliable way to determine which of the four SIMMs in a PC is defective. By placing all four SIMMs in the tester, you can determine which one is bad. $1395. **Darkhorse Systems Inc**, Austin, TX. (512) 258-5721. **Circle No. 359**

Ada comes to Pentium. A validated Ada development system targeting the Pentium processor is now available. The system includes a compiler and a Motif-based symbolic debugger. It is available hosted on VAX/VMS, SPARC SunOS, and Solaris workstations. Its output format is OMF-compatible, allowing use with third-party tools. Future versions of the software will include optimization for the Pentium's dual-instruction pipeline. **DCC-I Inc**, Phoenix, AZ. (602) 275-7172. **Circle No. 437**

STD card cage offers ISA slots. The ZT 211 series of STD-32 card cages provides 18 or 21 card slots for STD 32 boards and two card slots for ISA-bus PC add-in cards. The ISA cards fit into a protected enclosure at the rear of the cage and operate as if they were STD I/O cards. The cages also feature front-removable ac- and dc-power-supply modules, forced-air cooling, and provisions for either table or rack mounting. The cages meet IEEE specification P1156 for shock and vibration. Prices start at $1100. **Ziatech Corp**, San Luis Obispo, CA. (805) 541-0488. **Circle No. 438**



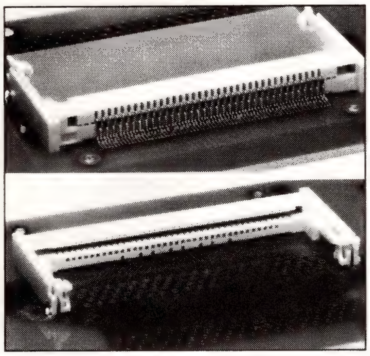
Embedded PC meets file server needs. With its built-in 486 processor, 32-Mbyte memory, Novell-compatible Ethernet interfaces, and three solid-state disks, the PC-450 can perform all the tasks of an office file server. The 6×8-in. board also offers an SVGA-display interface capable of driving color-LCDs and interfaces for keyboard, touchscreen, CD-ROM, and optical drives. The board provides DOS 6.0 in ROM, IDE and SCSI-2 ports, and an optional fiber-optic interface. Prices start at $2700. **Octagon Systems**, Westminster, CO. (303) 430-1500. **Circle No. 439**

PowerPC joins military VME. The CPU-601 is a single-width 6U VME board based on a 50-MHz PowerPC 601 processor. The board is compatible with VME64, IEEE 1014, and IEEE1101.2 specifications and is available in full MIL-SPEC or industrial versions. It includes as much as 4 Mbytes of flash memory, 2 kbytes of serial EEPROM, and two serial ports. The board comes with built-in test and monitor firmware. Pricing starts at $6000. **Radstone Technology Corp**, Montvale, NJ. (201) 368-2738. **Circle No. 440**

Pentium PCI-bus comes to Multibus II. Based on the 90-MHz Pentium Processor, the SBCP5090 board provides a high-performance, PC-compatible Multibus II board. The board

CIRCLE NO. 187

DOUBLE DENSITY MEMORY MODULE SOCKET WITH 72 POSITIONS

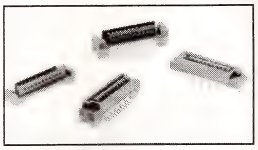


Hirose is offering the SX1 series of "double density" socket connectors for 72-position Small Outline SIMM (single in-line memory module). By offering .025" (0.635mm) versus .050" (1.27mm) lead termination spacing, Hirose's double density (double-sided) socket allows the module board to achieve a higher density while reducing the module board to half the size of existing 72-position boards. The SIMM, itself, actually increases the memory capacity of the module from 4Mb (DRAM IC) TO 16Mb high density IC. The right angle socket connector has a low profile of less than 6mm (0.236") when the module board is locked in, including the height of the module. Contacts are right angle SMT with spacing of 0.635mm. Applications for the SX1 series are personal computers, office automation equipment, medical equipment, factory automation equipment, game products, general purpose computers and measuring equipment.

For more information, contact **Hirose Electric (U.S.A.)**, (805) 522-7958 or fax (805) 522-3217. For catalog information via fax: 800-879-8071. Ask for #5017.

CIRCLE NO. 26

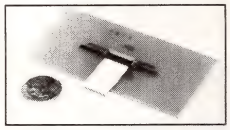
HALF-PITCH, TWO-PIECE CONNECTORS FOR SMT APPLICATIONS



Hirose is delivering the FX4 series of half-pitch (1.27mm, 0.050") surface mount connectors with stacking heights of 5 to 11mm between PCB's. Hirose also offers through hole styles which are available with stacking heights of 5 to 11mm. As a result of the continuing trend to miniaturization of equipment, Hirose designed the FX4 series of SMT connectors to satisfy the needs of smaller component sizes. While stacking heights can be set at 6, 6.5, 7, 7.5, 8, 8.5, 9, 10 and 11mm, contact design features low insertion and extraction forces. Available in 20, 32, 40, 52, 60, 68 and 80-positions, the FX4 SMT series is ideal for computers, peripherals, terminal equipment and a wide variety of office automation equipment.

For further information, contact **Hirose Electric (U.S.A.), Inc.**, (805) 522-7958 or FAX (805) 522-3217. For catalog information via fax: 800-879-8071. Ask for #5009. **CIRCLE NO. 27**

"FLIP-LOCK" SMT/ZIF TYPE FLEXIBLE PCB CONNECTOR



Hirose is producing the FH12 series of miniature connectors for FPC/FFC use. These newly developed connectors use a "flip-lock" concept and can be used with surface mount technology to prevent problems associated with slide-lock systems. The FH12 series connectors have spacing of 0.5mm (0.020") and are suited to high density mounting, with a mounting height of only 2mm. The new connector has also been reduced by 1.7mm in length compared to earlier Hirose products. It is available with 10, 15, 20, 24, 30, 33, 36, 40, 45 and 50-positions. Hirose's one-touch ZIF (zero insertion force) technology offers labor-savings, even with multiple contacts. Ideal for LCD-related uses, as well as portable telephones, CD-ROM and other miniature products.

For further information, contact **Hirose Electric (U.S.A.), Inc.**, (805) 522-7958 or FAX (805) 522-3217. For catalog information via fax: 800-879-8071. Ask for #5018. **CIRCLE NO. 28**

Just when you thought you have seen everything in PC card connector technology, Hirose presents more surprises.

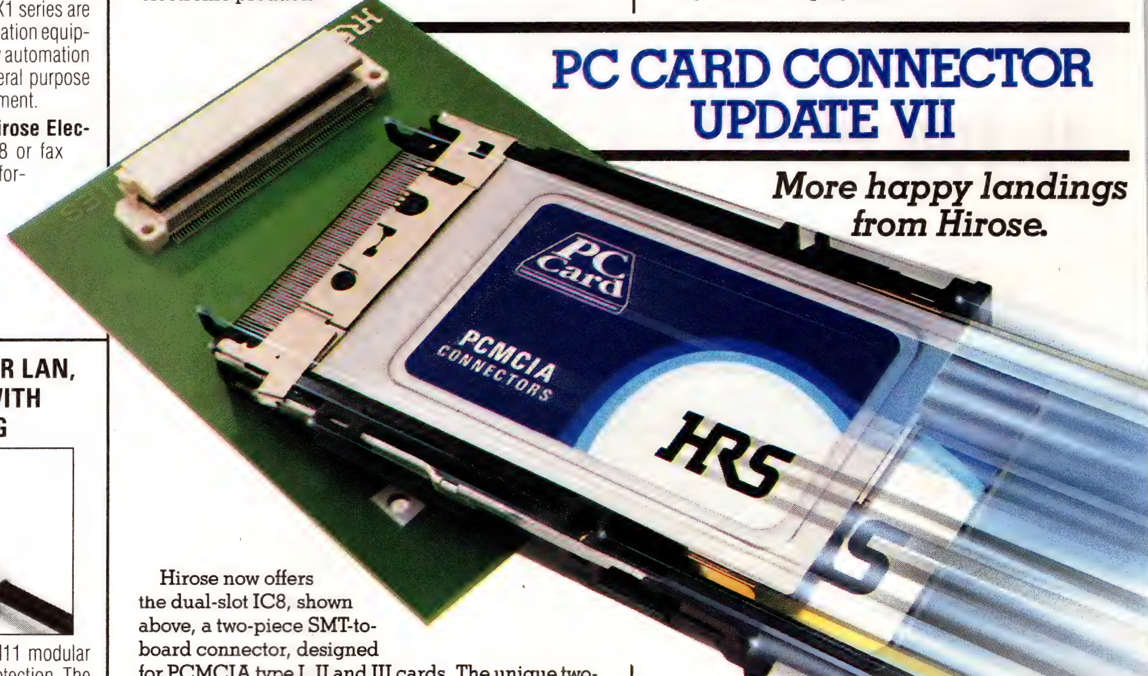
For Hirose customers, though, these compact solutions are expected. Because every day, Hirose helps design engineers package compact memory and I/O capability into sophisticated, compact eléctronic products.

If you are looking for alternative designs, consider the IC6 series of dual-slot PC card header connectors. These through-hole connectors are available in high-temp or value-engineered versions, and will take Type I, II and III cards.

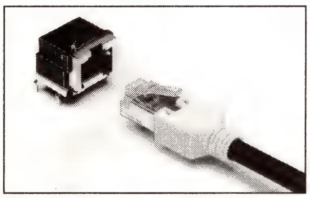
Learn how Hirose can make your PCMCIA card interconnects, with ESD and EMI protection, work on your current projects.

PC CARD CONNECTOR UPDATE VII

More happy landings from Hirose.



TM CONNECTORS FOR LAN, ISDN AND PC's WITH EMI SHIELDING



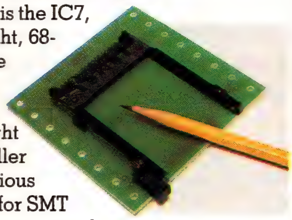
Hirose is offering a new line TM11 modular connectors with EMI shielding protection. The one-piece construction of the shell and clamp provide excellent EMI protection for ISDN terminals and personal computers, LAN boards and for the datacom industry. In order to protect equipment circuitry, the jack is built to allow the shielding to easily engage and lock first upon mating. A metal shell offers ESD protection and a plastic cover is provided for enhanced aesthetics. Available in either 6 or 8-positions, the TM11 connector is a popular replacement for the industry standard RJ45 and is now being widely accepted for building wiring applications.

For further information, contact **Hirose Electric (U.S.A.), Inc.**, (805) 522-7958 or FAX (805) 522-3217. For catalog information via fax: 800-879-8071. Ask for #3002.

CIRCLE NO. 29

Hirose now offers the dual-slot IC8, shown above, a two-piece SMT-to-board connector, designed for PCMCIA type I, II and III cards. The unique two-piece construction provides full access to the SMT contacts. Note in the drawings how the clip-on ejector moves in to dock with the SMT connector.

Shown on the right is the IC7, a compact, light-weight, 68-pin connector suitable for PCMCIA Type I, II and III cards.



About half the weight and substantially smaller and thinner than previous product, it is suitable for SMT or through-hole mounting, standard or reverse placement under the PCB and with options of left or right hand eject buttons. The choice is yours.

Circle No. 30

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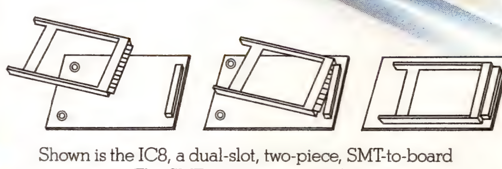
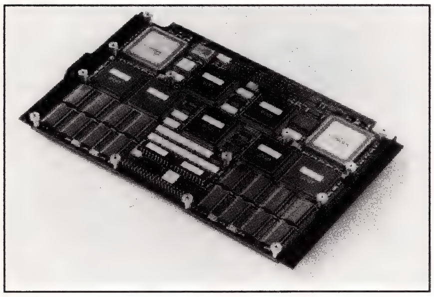


Shown is the IC8, a dual-slot, two-piece, SMT-to-board connector. The SMT portion provides full access for visual inspection of solder terminations.

HRS

Hirose Electric (U.S.A.), Inc.
2688 Westhills Court, Simi Valley, CA 93065-6235 • (805) 522-7958
FAX (805) 522-3217. For instant fax catalog information: 1-800-879-8071. On the IC6, ask for #8005. On the IC7, ask for #8008, on the IC8, ask for #8009.

includes both a PC BIOS and Multibus system software in flash memory, allowing use of off-the-shelf software such as DOS or PC Unix. The board also incorporates a PCI-to-Multibus bridge ASIC that allows PCI peripherals to pass data directly to the bus. IDE, Ethernet, and SCSI-2 interfaces on the PCI bus come standard with the board. An SVGA controller is available as an optional add-on module. Board memory can be as large as 128 Mbytes, and board memory is added using standard SIMMs. Software support for the board includes iRMX, Windows, and Univel UnixWare. Prices start at $6495. **Intel Corp**, Santa Clara, CA. (800) 438-4769. **Circle No. 441**



Military vector processor provides 160 Mflops. Using dual i860 processors sharing as much as 16 Mbytes of memory, the VSP-1 vector signal processor provides 160 Mflops of sustained compute power in a single VME slot. Each processor has an independent datapath to memory through a crossbar switch. A separate i960 processor handles communications and data transfers to the VME bus. The board comes with a programmer's tool kit and is supported by Wind River's VxWorks. The VSP-1 is available in full MIL-SPEC and ruggedized commercial versions with prices starting at $23,530. **Radstone Technology Corp**, Montvale, NJ. (201) 391-2700. **Circle No. 442**

Real-time kernel runs on PA-RISC CPU. A version of C Executive, a ROMable multitasking system operating kernel, is now available for the PA-RISC architecture. The version is designed to run on the Oki OP50N embedded μP version of PA-RISC with the Densan DVE-OP50N/12 development board as the target. The development tools include a Hewlett-Packard ANSI-C compiler. In addition to the real-time kernel, C Executive offers an optional file system, a debugger, and a TCP/IP communications package. **JMI Software Systems Inc**, Spring House, PA. (215) 628-0840. **Circle No. 443**

PowerPC card takes PCI. Offering the PowerPC 603 processor as its core, the Power*3 board provides a VME64 bus interface and a PCI local mezzanine bus. The board accepts 512 kbytes of EPROM for holding the operating system, has as much as 128 Mbytes of DRAM, and runs at either 66 or 80 MHz. The VxWorks and RTMX operating systems are available for the board, with Solaris, OS-9000, pSOS, and LynxOS available later in the year. Price is <$4000. **VI Computer Corp**, Encinitas, CA. (619) 632-5823. **Circle No. 444**

Modular kernel supports standard tools. The PXROM+ modular real-time kernel works with industry-standard compilers, debuggers, and in-circuit emulators. The basic kernel provides multitasking, events, semaphores, and intertask communications. Installable system modules include RAM disk, SCSI support, and flat- or hierarchical-file systems. The kernel will be available first for use with Microtec Research's Xray development software. License cost is $4000 for the first seat, additional seats cost as little as $1500, and annual maintenance fees are 20%. **Eyring Corp**, Midvale, UT. (801) 561-1111. **Circle No. 445**

Software migrates Unix GUIs to Windows. Part of a family of client/server tools for building graphical user interfaces (GUIs), the TeleUse/Win software module allows cross development between Unix and Windows. The module runs under Unix and generates native Microsoft Foundation Class (MFC) C++ code. The code can then run under Windows-based Visual C++. The module automatically maps Motif widgets and their resources to objects. A single license costs $1890. **Alsys Inc**, San Diego, CA. (619) 457-2700. **Circle No. 446**

VME boards ride the AutoBahn. The VM42A is a 3U VME board that contains the AutoBahn Spanceiver. The Spanceiver provides a data transfer rate of 200 Mbytes/sec and 128 kbytes of dual-port SRAM buffer for linking CPUs together. The board contains a 50-MHz 68040 processor and a 25-MHz 68EN360 communications controller. It also offers a CXM mezzanine bus for Ethernet or other communications options. $2355; boards will be available in the third quarter. **PEPModular Computers**, Scottsdale, AZ. (602) 483-7100. **Circle No. 447**

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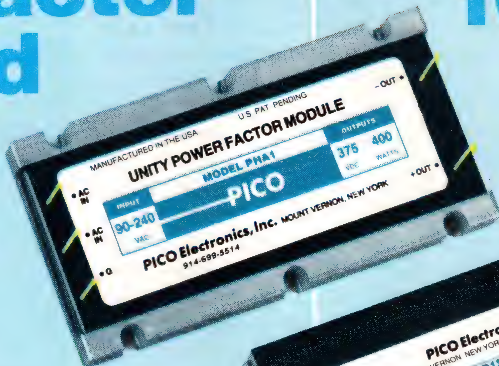

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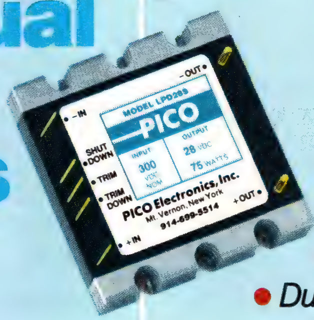

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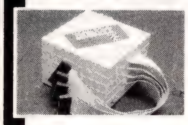

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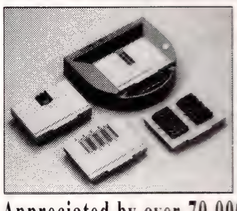

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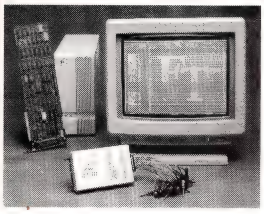

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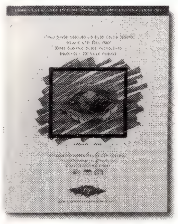

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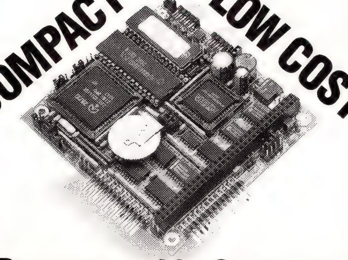

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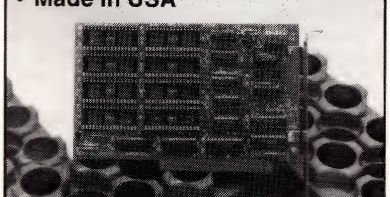

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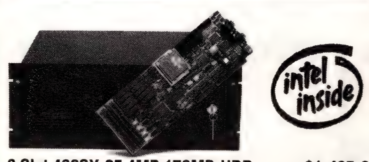

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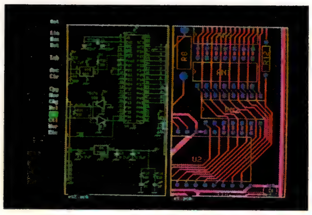

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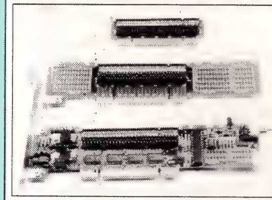

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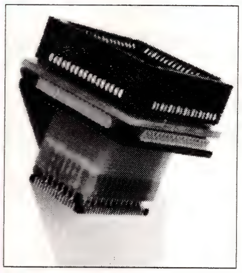

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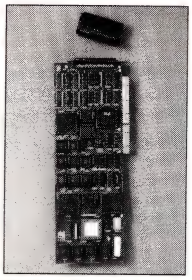

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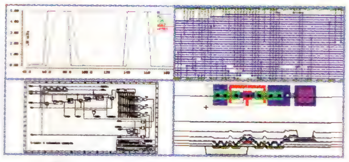

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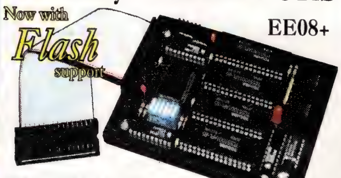

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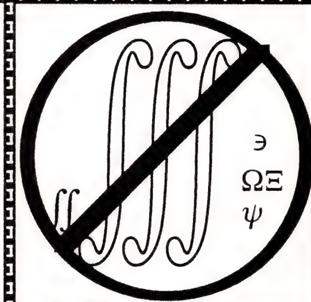

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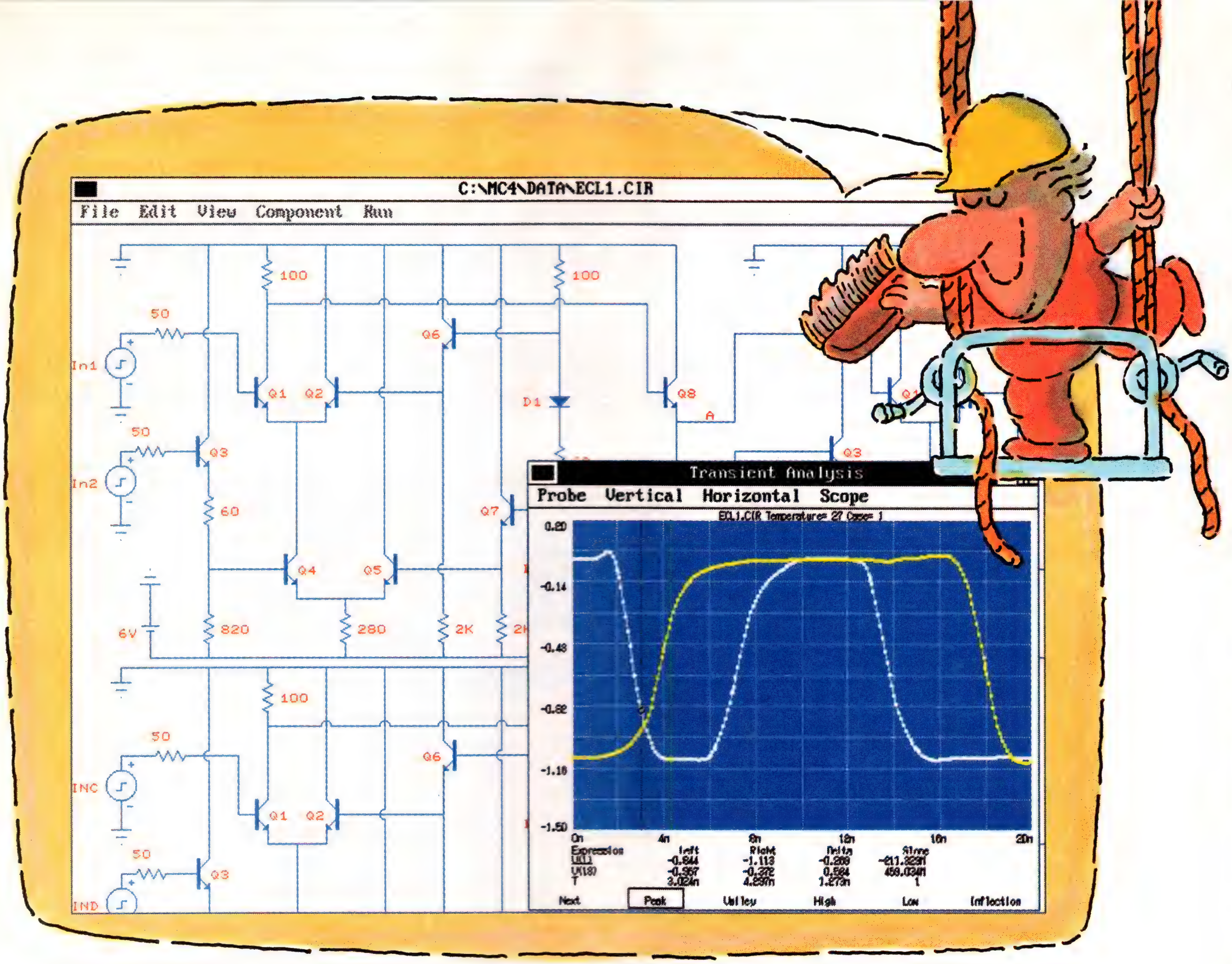

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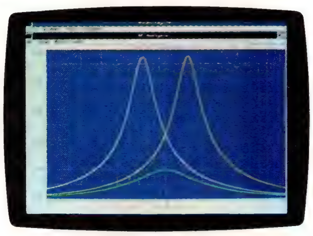

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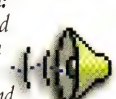

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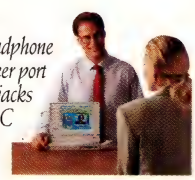

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The paperless office: must or myth?

Experienced engineers know that a new college graduate is really nothing more than a blank slate with no experience and little practical knowledge. The four years of cramming Maxwell's equations and cranking triple integrals give a nice theoretical grounding in the basis of our profession but leaves much lacking that only on-the-job training can fulfill. I remember that our instructor did not allow us to solder in our lab courses because he feared we might burn ourselves. Appalling, but true.

Your white-collar self-esteem may bristle at these words, but engineering is very much like the trades people practiced hundreds of years ago. We've substituted "junior engineer" for the word "apprentice" and "senior engineer" for "journeyman," but master craftsmen hand down most of the practical aspects of our profession to newcomers.

"The most important system for manufacturing and engineering is the drawing-control system."

This isn't bad; because technology has a half-life of, perhaps, three to five years, no college could ever adequately prepare engineers for the work place. An engineer not constantly involved in self-education becomes obsolete in short order.

One thing we never discussed in college was drawings—amazing, since most engineering output is nothing but drawings. Sure, we sketched a few simple schematics and analyzed circuits on the blackboard, but, somehow, we never addressed the creation, maintenance, and updating of the drawings that are the product of our work.

Every small company goes through a phase of creative chaos. Crank out a few sheets of OrCAD schematics and hand-annotated assembly drawings, and *ship the product*. In time, the product line broadens, necessitating more drawings (all stored in a drawer somewhere). Management expects new hires to build and maintain the products, often working from memory. They'll often hear comments like "Oh yeah, we always put a 10k resistor in that spot," or "Jeez, you forgot the mod we do to that version of the product."

This is a classic case of the company's systems breaking down. Management texts talk about planning and inventory-control systems but ignore the most important system for manufacturing and engineering: the drawing-control system.

My company went through this evolutionary phase, during which it accumulated hundreds of drawings. Sure, we had bills of materials and assembly drawings, but they were impossible to track. Which was the current version? What changes were implemented between versions?

In desperation, I tasked a young engineer with developing a formal drawing system, not realizing that, having had no experience with functioning systems, he had no idea where to start. The result was, well, primitive.

On a memorable cross-country flight shortly thereafter, I pounded in a specification for a document-control system, drawing on the experience I had obtained as a junior engineer years before. Frankly, I pirated the concepts from a former employer. That system, in turn, is derived from one used by the airplane industry. Though our system has refinements for handling embedded designs (PAL and ROM files, for example), it looks much like any system dating from the '50s or even '40s.

Now, I secretly smile, realizing that my company's crop of engineers will probably take this third-generation system along to other employers in the future, keeping many of the core concepts for two simple reasons: It works, and it has become another comfortable tool in their skills bag in their journey toward master craftsmanship. There is nothing new under the sun!

Teaching apprentices is very much like having children. Your own kid is a source of genetic immortality; the protégé you mentor likewise perpetuates a piece of you.

The paperless office

Although journalists have written plenty about the evolution to the paperless office, few technology companies have made this transition, even in the highest of the high-tech environments—engineering. Sure, we now use schematic capture instead of a pencil and vellum, and word processors rather than scrawled notes. But almost all electronic documents get reincarnated in paper form.

The paperless drawing system described in this article is available on the EDN Readers' BBS (computer bulletin-board system). Phone (617) 558-4241 with modem settings 1200/2400 8,N,1. From the Main System Menu enter *SS/freeware* and then from the /freeware SIG menu enter *rkGAN1894*.

PHOTOGRAPHY / HOWARD DAVIS

Production wants paper drawings for the assemblers. Test needs test procedures and schematics on paper. Let's face it: Even engineering wants the schematics on paper. You can scribble and make notes on a paper schematic. You can't do that on screen.

Electronic documents suffer from another flaw: Every drawing runs under a different application! Schematics use one of dozens of capture packages; assembly drawings may be in AutoCAD or another format; even text documents can be in Word, Lotus, or any of a hundred other formats. You cannot display and manipulate all of the system's documents unless you own all of the applications on your workstation.

Does this suggest that an organization should standardize on a single word processor, single database, and the like? That's the tack we've taken.

The new reality of a drawing-control system must recognize that, although masters are inevitably in some computer format, working copies are almost always on paper. Paper is *not* bad per se; it is yet another component of a modern information-management system.

To handle the realities of standard office equipment, all schematics and other documents should, if possible, be formatted for 8.5×11-in. paper. The days of D-sized schematics are long gone. You can't copy them without a monstrous blueprint machine, you can't fax them, and you can't store them without special cabinets. My company's entire drawing system fits in one drawer of a standard file cabinet—a space-conserving, easy-access format that greatly simplifies life.

"But," you sputter, "we've always used huge drawings!" Times and technology change. Embrace change. My dad says that in the pre-Mylar days they did drawings on starched linen in ink. One bead of sweat in those pre-air-conditioned '50s could ruin a week's work.

When I first entered this field, all we managed were drawings and bills of materials. The digital age has only increased the kinds of "documents" any reasonable drawing system must manage.

Perhaps, though, it makes sense to outline the goals of a document-control system:

1. Guarantee that all departments are using accurate, up-to-date, drawings.
2. Control product versions, so production knows how to make each kind of product.
3. Provide a historical record of changes, so the service group can bring older products up to current revisions without heroics.
4. Ensure that adequate backups exist so that the knowledge in the system can survive a fire or malicious intent.

Goals 1 to 3 have been around since the dawn of engineering. I suppose John and Washington Roebling themselves built the Brooklyn Bridge with a primitive drawing system that obviously functioned well. The fourth goal is a result of challenges from the computer age and the realization that a company must survive despite any disaster.

Almost all electronic documents get reincarnated in paper form.

How do you manage a document that lives in some purely electronic form? Schematics and artwork should have paper (or film) copies filed in the drawing drawer, but what about the original files?

One solution is to define an electronic repository. At my company, one computer has a master directory, available to everyone over the network, where a copy of every critical file is stored. Modern networks are great because even a simple one lets you define read/write access rules and passwords. There's little problem leaving these files available to everyone, but a paranoid outfit could easily restrict write-access to those folks with a "need to write."

Every project has its own subdirectory, with further subdirectories containing ROM, PAL, CAD, and word-processing files. Draconian rules and an assigned "enforcer" ensure that changes to the files get copied back to the master computer.

With all of the files on one machine, it's easy to run weekly backups to tape. In effect, we can back up everything critical to the business in 30 minutes from a single machine and need not rely on forgetful and busy employees to run regular backups of their own systems. In a break-in a year ago, a burglar destroyed or stole almost every decent computer. Yet we lost virtually no data.

PALs and ROMs pose special documentation challenges, because they are physical devices that you must purchase. As a result, they require call-out on a bill of materials. Yet, the device itself is incomplete until it is burned with the proper equations or program. Our solution is to call out the chip on the bill of materials, with an associated drawing number that describes the part's programming.

The ROM/PAL drawing includes the file names of all source-code modules used to build the equations or program. PALs are always a single .PDS file compiled via PALASM. ROMs invariably are composed of dozens of source-code modules. By listing every file used, its full file name on the master computer, and the required make files, it's possible to re-create the program from the backup files, even if a software engineer's computer dies (or is stolen).

No system can work unless it's clearly understood who is in charge of keeping it up to date. Tasking an individual with the responsibility of managing the drawing system means everyone knows whom to turn to for help and advice. The responsible individual knows what is expected, and management can crack the whip. The drawing system is too important to leave to chance. Its management should be part of the responsible person's annual review.

The E Myth by Michael E Gerber (1986, Harper Business, New York) examines how businesses start, grow, and sometimes choke on their own success. The book's most important point is that the entrepreneur should work *on*, not *in* the business. That is, spend time designing systems and procedures that make it possible for the business to thrive, despite its success.

Though Gerber never mentions drawing systems, document management is surely as important as any other system. EDN

Jack Ganssle is the president of Softaid, a vendor of emulators and other embedded-systems tools. His idea of heaven is sailing across oceans, although the ugly face of common sense precludes these dreams too often. Contact him via Compuserve at "76366,3333," or via Internet at "76366.3333@compuserve.com." Send mail c/o Softaid, 8310 Guilford Rd, Columbia, MD 21046.

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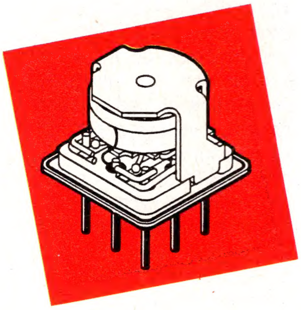

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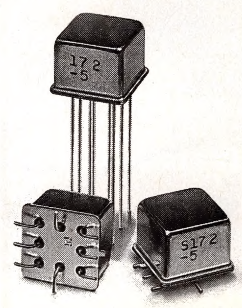

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